POWER PLANT ENGINEERING

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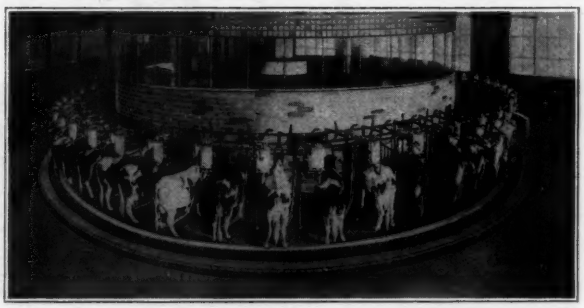


A Cow Carousel

"LISTEN, BESS, as one girl to another, do you think this merry-go-round stuff is all it's cracked up to be?"

"Not me, dearie. I don't like to knock but I think it's an outrage the way they treat us. Why, it's getting so a respectable cow has no rights at all ——"

"Those are my sentiments exactly, my dear. It's terrible—we don't have any privacy any more. It isn't enough to be milked by these terrible mechanical contraptions but they don't even trust us. Some fresh chemist is always doubting the quality of our milk. Now, in the old days ——"

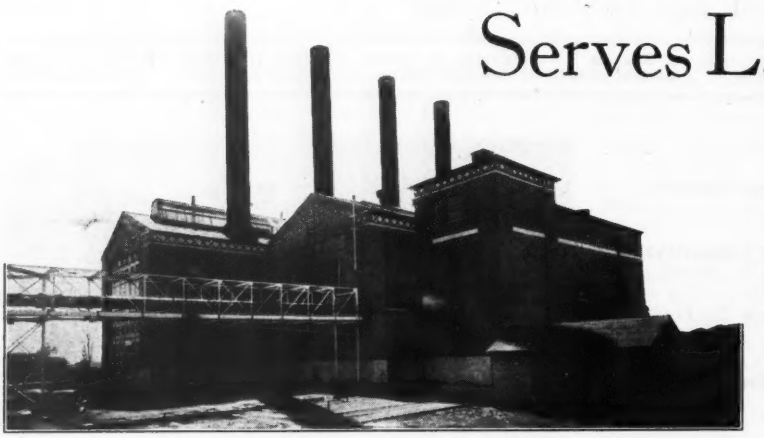
"That's just it. No wonder our milk tests low; the way they whirl us around on this devilish thing it's a wonder it isn't churned by the time it's delivered."

"Yes, and then the way they make us take a bath twice a day is an insult to our dignity—why, my grandmother in Jersey never took a bath and didn't she become famous?"

"Well, of course, us Holsteins always were noted for being clean but the smell of that antiseptic stuff they wash us with is enough to congeal my lacteal product. Only yesterday out in the pasture, my boy friend wanted to know what new perfume I was using. I was so mortified I swallowed my cud twice more than usual. Porterhouse, my boy friend, of course is too bully a fellow to say anything but I know what he was thinking."

We didn't stop to hear the end of this bovine meeting of protest but we don't blame the poor cows. Just look at the above picture. This milking system used at the Walker-Gordon farm in New Jersey milks cows automatically at the rate of 240 per hr. The merry-go-round has 50 stalls and revolves once in 12½ min. During this time each cow is washed, dried and milked, the milk of each cow measured, registered and delivered to the bottling room while the De Laval magnetic milking apparatus is rinsed, sterilized and cooled, to be ready for the next cow. Power? Oh, yes, of course, it is electrically driven through De Laval gears having a reducing ratio of 700 to 1.

Louisiana Steam Products Plant Serves Large Industry



LARGE MODERN PLANT WITH 45,000 KW. IN THREE 600-LB., 140-LB. BACK PRESSURE UNITS AND FOUR 13,800-SQ. FT. BOILERS USING GAS AND REFINERY WASTE FUEL SUPPLIES STEAM AND POWER TO THE NEARBY STANDARD OIL REFINERY AND POWER TO AN INTERCONNECTED SYSTEM. BY C. R. STEWART*

DREAMS OF A MULTITUDE of steam plant engineers in which there appeared a modern steam electric plant serving both industry and the general public, without the usual extensive waste of heat in condenser cooling water, are realized in the new Louisiana Station of the Louisiana Steam Products, Inc., at Baton Rouge, La.

Steam destined for the industry is used to carry an extra load of heat from the boilers to the turbines where it is utilized at high efficiency for the generation of electrical power which is used partly by the industry and partly by a public utility. The exhaust from the turbines carries the heat required by the industry most of which is latent heat that would ordinarily be lost in the cooling water of a condensing plant.

This station, with steam generating capacity of over 1,300,000 lb. per hr. at 625 lb. pressure, more than half of which amount is delivered regularly to a neighboring oil refinery at 135 lb. pressure, has several unusual features. The principal of these are noncondensing, non-extraction type turbines with rated generator capacity totaling 45,000 kw., a large feedwater purifying plant, a three-stage feedwater heating system and equipment to burn at high boiler ratings refinery waste fuels up to 50 per cent of the total fuel requirements of the boilers.

In considering the general design of the station, the natural inclination to adhere to the cheaper types of construction ordinarily used for industrial plants was modified by the need for high economy justified by the size of the station and its very high load factor; consequently, it was decided to use the cheaper type of construction for the building but to install the best plant equipment obtainable. Simplicity of arrangement was a major consideration.

About 75 per cent of the steam generated goes from the turbine exhaust to the industry.

Delivery of steam was required seven months after signing the contract with the refinery. The limited time available for construction was an important factor affecting to a considerable extent the choice of major equipment. The entire design was worked out to assure the continuity of steam supply to the industry. This condition, together with the desirability of keeping the main turbines of very simple design, led to the decision to use an arrangement in which all of the high pressure steam passes through the main turbines from which about 75 per cent goes directly to the industry. The balance is used by the station auxiliaries and is eventually returned to the feedwater heating system. The steam used by the boiler feed pump turbines is exhausted to a low-pressure heater at about 4 lb. absolute pressure, while the steam used by the forced and induced draft fan turbines, is exhausted to deaerating heaters at about 2 lb. gage pressure. Another portion of the main turbine exhaust steam goes directly to the high pressure heater.

No condensate returns are obtained from the industry, and in consequence approximately 80 per cent of the boiler feed is make-up consisting of treated Mis-

*With Stone & Webster Engineering Corp.

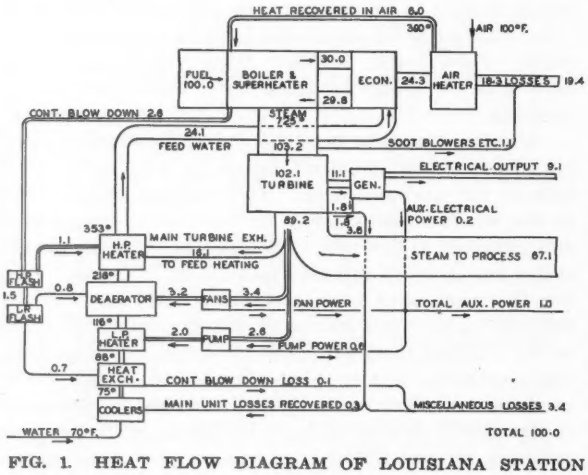


FIG. 1. HEAT FLOW DIAGRAM OF LOUISIANA STATION

sissippi River water. This makes necessary the blowing down of 10 to 15 per cent of the total boiler feedwater to maintain the concentration of dissolved solids in the boilers within safe limits. This blowing down is done continuously. The water is allowed to flash down to near atmospheric pressure in two stages and is finally cooled in a heat exchanger with almost complete recovery of heat carried from the boilers.

A group of automatic pressure reducing valves with automatic desuperheaters has been provided in the main high pressure steam piping. These will come into service when the steam demand exceeds the output of the turbines in service. Normally the electrical output of the station will be controlled entirely by the demand for 140 lb. steam. The electrical power generated in excess of that required by the industry will go to the lines of the Baton Rouge Electric Co. and of the Gulf States Utilities.

Steam generating equipment consists of four units, each consisting of one straight tube, 40 wide, 12 high, cross drum boiler of 13,800 sq. ft. heating surface, a convection type superheater, an economizer of 9800 sq. ft. surface and a plate type air heater of 32,800 sq. ft. surface. The furnaces are equipped with water-cooled walls on four sides and combination gas, oil and pulverized coke burners. These units each have a maximum rating of 364,000 lb. per hr. of steam at 625 lb. gage and 750 deg. F. temperature.

Each boiler unit is provided with one 109,000-cu. ft. per min., 1050-r.p.m. forced draft fan and two 84,000-cu. ft. per min., 1186-r.p.m. induced draft fans. Each fan is driven through a reduction gear by a 270-hp., 4450-r.p.m. steam turbine, exhausting at 3 lb. gage pressure. Individual superimposed steel stacks with acid resisting brick linings are provided.

Boiler feed pumps are the 5-stg. centrifugal type, direct connected to 2400-r.p.m. condensing steam turbines of 930 hp. capacity. There are four pumps each rated 1500 gal. per min.

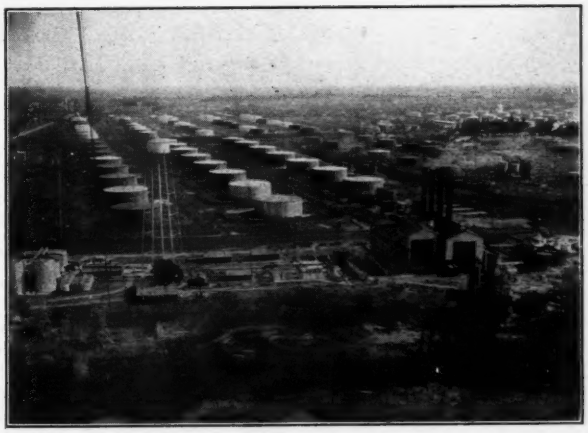


FIG. 2. GENERAL ARRANGEMENT PHOTOGRAPH WITH THE WATER SOFTENING ON THE LEFT, FUEL STORAGE TANKS AT THE RIGHT AND THE REFINERY AND TANK FARM IN THE BACKGROUND

Boiler feedwater pressure is controlled by load pressure regulators which adjust the steam supply to the pump turbines. Combustion control consists of a master device actuated by the pressure in the main steam header. This device controls the setting of regulators which vary the induced draft and gas fuel pressures as required to maintain a constant pressure on the steam header. Furnace pressure is held constant by regulators controlling the speed of forced draft fan turbines. No automatic control is provided for waste fuel or fuel oil supplies.

Generating Equipment

Main turbine generator equipment consists of three units, each of 15,000 kw. rated capacity. Turbines are of the combined impulse and reaction type, 3600 r.p.m., designed to exhaust at 140 lb. ga. Direct connected exciters are provided and a separate spare turbine driven exciter set is also included.

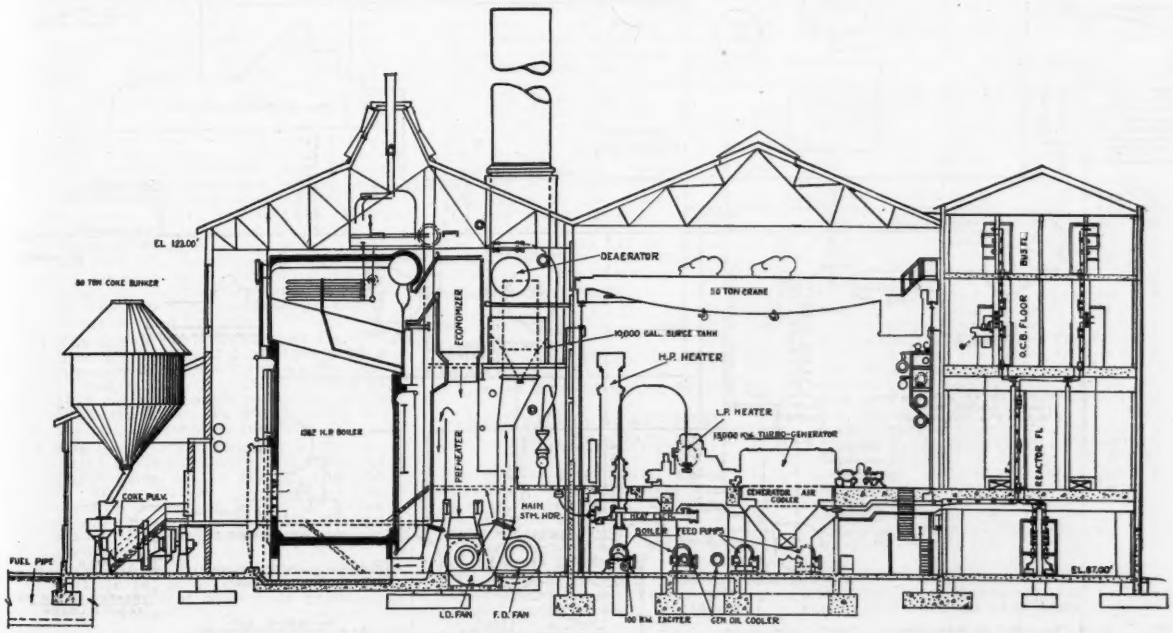


FIG. 3. CROSS SECTION SHOWING THE ARRANGEMENT OF EQUIPMENT

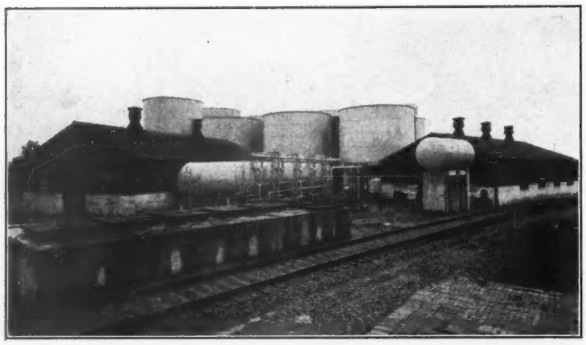


FIG. 4. WATER SOFTENING STATION

Electrical generation is at 13,800 v., 60 cycles, 3 phase, and power is delivered to the industry and to the Baton Rouge Electric Co. without transformation. All plant auxiliary circuits are 440 v., three-phase, the power for which is supplied from duplicate 1500-kw., three-phase transformers connected to the generator bus. An outdoor transformer bank of 30,000-kw. capacity delivers power to a 66,000-v. river crossing line which connects to the Gulf States Utilities Co.'s system.

Water Supply

Water supply formed a major problem, with both the Mississippi River and deep wells as possible sources. River water was adopted because after suitable treatment it would be more desirable for concentration in the boilers. The shifting nature of the river bank and extreme variations of about 45 ft. in the river level makes the building of any permanent intake structure expensive, so a semi-permanent pile structure and trestle was built projecting into the river and with two 3000-g.p.m. motor-driven well type pumps located in well casings at the outer end. A 16-in. steel pipe line, supported on the deck of the trestle above the high water line, conveys water to the treating plant. A spare connection to provide water supply in case of interruption of service from the trestle structure was brought in from the lines of a neighboring industry.

An unusually complete water purification plant of 2000-g.p.m. normal capacity was installed. The treatment consists of continuous presettling, batch precipitation of carbonates with lime and coagulants, filtration, addition of acid to control the alkalinity and augment the sulphate content, aeration to remove CO_2, softening with zeolites, followed by the addition of caustic and phosphate all in the order mentioned. A 200,000-gal. elevated storage tank of treated water provides reserve against a short interruption. Three 2000-g.p.m., 260-ft. head motor-driven pumps handle the normal supply through the softeners and to the plant.

Waste Fuels and Natural Gas Used

Natural gas from the Monroe, Louisiana, field forms about 50 per cent of the normal fuel and all burners are arranged to burn gas as well as one or more of the other fuels. Fuel oil is held in reserve for use in case of failure of the gas supply. The handling, preparation and burning at high ratings of liquid waste fuels are difficult problems, due to the highly corrosive nature of some of the fuels and to their variable quality which ranges from the fluidity of water to the consistency of heavy tar with wide variation in water and acid content. Formerly burning of these fuels has been at low ratings, using steam atomization, but to obtain high efficiency and high capacity it was necessary to use mechanical atomization. Storage, heating and pumping equipment and piping for three types of liquid waste fuels are provided.

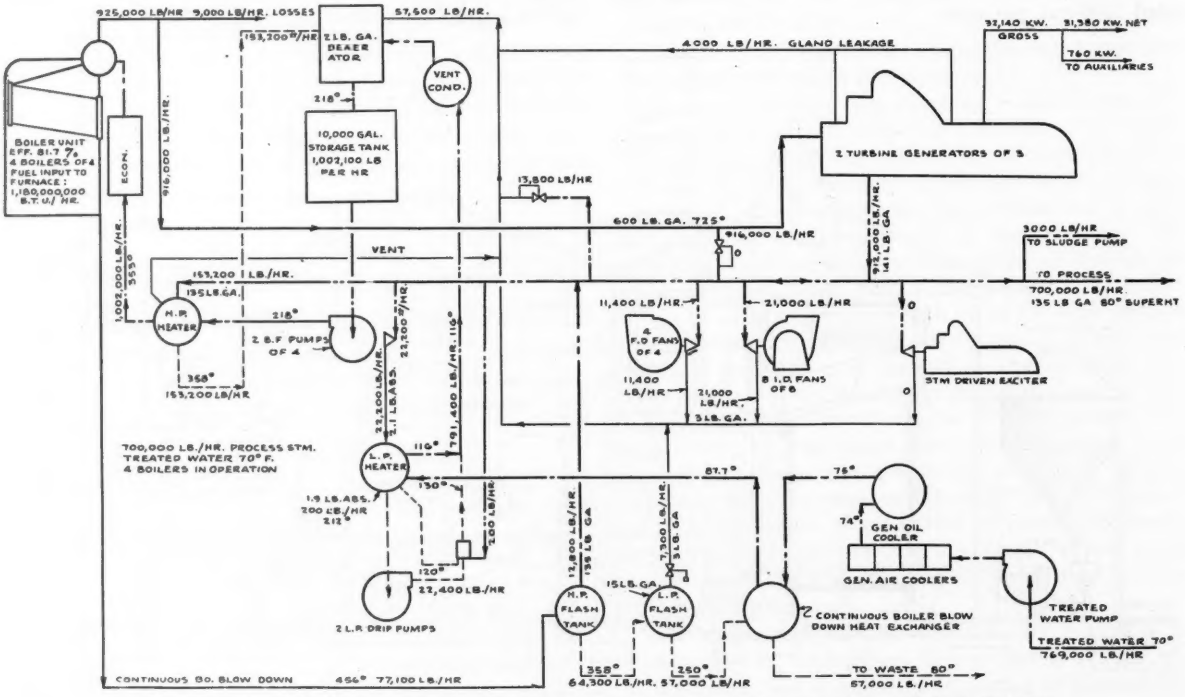


FIG. 5. HEAT BALANCE AT 31,380 KW. NET AND 769,000 LB. PER HR. OF 80 DEG. F. WATER

Principal Equipment of the Louisiana Station

GENERAL

Designed and built by Stone & Webster Engineering Corp. for the purpose of supplying process steam and power to the Standard Oil Co., of Louisiana and power to an interconnected system. The plant is located on the east shore of the Mississippi river about 4 miles north of Baton Rouge, La. Generating capacity of this station is 45,000 kw. non-condensing. Boiler room measures 89 ft. 8 in. by 196 ft., the turbine room, 64 ft. 8 in. by 116 ft. 9 in. and the elctrical bay 34 ft. 8 in. by 115 ft. Fuels burned, natural gas and refinery residuals with fuel oil in reserve, have the following heat values:

Natural gas.....994 B.t.u./cu. ft.
Cracking coil coke.....14,000 B.t.u./lb.
Crude still coke.....14,000 B.t.u./lb.
Fuel oil .....18,000 B.t.u./lb.
Lubricating sludge .... 10,000-13,000 B.t.u./lb.
Acid tar .....13,000 B.t.u./lb.
Wax tailings .....13,000 B.t.u./lb.
Soda Bottoms .....13,000 B.t.u./lb.

BOILER ROOM

4 Babcock & Wilcox Co. 13,817 sq. ft., 670 lb., straight tube, cross-drum boilers with a maximum steaming capacity, each, of 350,000 lb. per hr., and baffled for three passes. Convection superheaters located between the tube bank and the circulating tubes are designed to heat the maximum boiler capacity of 350,000 lb. per hr. to 750 deg. F.

4 Babcock & Wilcox Co. 9,801 sq. ft., horizontal, counterflow, steel tube economizers with a maximum capacity of 350,000 lb. per hr. Water temperatures, in 350 deg. F., out 438 deg. F., water pressure drop 50 lb. per sq. in. Temperature of flue gas leaving 638 deg. F., draft loss 1.9 in. of water.

4 Babcock & Wilcox Co. 32,800 sq. ft. plate type air heaters designed for a maximum air flow of 345,500 lb. per hr. and a maximum flue gas flow of 384,500 lb. per hr. Flue gas, in 638 deg. F., out 369 deg. F., draft loss 3.20 in. of water. Air temperatures, in 80 deg. F., out 439 deg. F., air pressure drop 3.10 in. of water.

4 Fuller Lehigh Co. Bailey with water walls, front wall, 574 sq. ft., rear wall 369 sq. ft. and side walls 960 sq. ft. total.
The furnace is 26 ft. 2 in. wide, 20 ft. 6 in. deep and 28 ft. 6 in. high, and has an effective volume of 16,800 cu. ft.

2 Foster Wheeler Corp. 5500 lb. per hr. Hardinge Co. pulverizers, driven at 26 r.p.m. by 75-hp., 440-v., 435-r.p.m. General Electric Squirrel-cage induction motors through herringbone reduction gears. Designed to pulverize 80 per cent through 200 mesh with 400 deg. F. air. Each unit complete with an exhauster, driven by a 25-hp., 1750-r.p.m., 440-v., General Electric Co. double squirrel cage induction motor and with a belt-driven feeder, driven by a ¼-hp., 110-v., single-phase General Electric induction motor.

70 Peabody Engineering Corp. fuel burners, 42 combination gas and oil burners of straight mechanical type, 24 combination gas and oil burners of wide range type and 4 Toronto type burners.

4 The Green Fuel Economizer Co. turbine driven forced draft fans with a capacity of 109,000 c.f.m. at 100 deg. F. and 11.2 in. of water. Driven at 1050 r.p.m. through reduction gears by Terry Steam Turbine Co. 135-lb., 270-hp., 4440-r.p.m. turbines.

8 The Green Fuel Economizer Co. induced draft fans with a capacity of 84,000 c.f.m. at 375 deg. F. and 10.3 in H_2O. Driven at 1186 r.p.m. through reduction gears by Terry Steam Turbine Co. 135-lb., 228-hp., 4450-r.p.m. noncondensing steam turbines.

4 Birmingham Tank Co. steel stacks, 9 ft. 10 in. in diameter and 129 ft. 6 in. in height with acid resisting brick lining.

Air and Flue Gas Ducts..... ....R. D. Cole Mfg. Co.
Burner Wind Boxes..... .....Birmingham Tank Co.
Combustion Control ....Smoot Engineering Corp.
Feedwater Regulators.....Stets Co.
Soot Blowers ....Diamond Power Specialty Corp.
Stack Lining and Paint..... Anchor Packing Co., Nightingale & Childs Cos., Quigley Co., Inc., Semet-Solvay Eng. Corp.
Refractories, tile and cement..... Armstrong Cork & Insulation Co., Botfield Refractories Co., Eastern Clay Goods Co., Evans & Howard Fire Brick Co., General Refractories Co., A. P. Green Fire Brick Co., North American Refractories Co., Quigley Co., Inc.

FUELS HANDLING EQUIPMENT

1 Pennsylvania Crusher Co. 35 t. per hr. coke crusher driven by a 30-hp., 440-v. General Electric motor.

1 Stephens-Adamson Mfg. Co. coke handling system, consisting of track hopper, girders and grating; reciprocating plate feeder; inclined belt conveyor from crusher pit to junction tower; inclined belt conveyor from junction tower to distributing tower; two motor-driven inclined belt conveyors from the distributing tower to coke bins; drive mechanisms for plate feeder and belt conveyors, and steel supporting structure. Reciprocating feeder and belt conveyors all driven by General Electric 440-v. motors.

4 Quimby Pump Co. screw type fuel oil pumps; 2 60-g.p.m. electric drive; 1 30-g.p.m. electric drive; 1 30-g.p.m. turbine drive. Discharge head, 309 lb.

2 Schutte & Koerting Co. steam jet exhausters for fuel oil pump priming and vacuum drip tank discharge.

2 National Transit Pump & Machinery Co. 12 by 5½ by 12-in. horizontal duplex lubricating sludge pumps operating at 135 lb. steam pressure and with a capacity of 90 g.p.m. each against a back pressure of 275 lb. per sq. in. Piston speed, 39 ft. per min.

2 National Transit Pump & Machine Co. horizontal, single-cylinder acid tar pumps operating on 135 lb. steam pressure and with a capacity of 40 g.p.m. each against a discharge pressure of 275 lb.

2 National Transit Pump & Machine Co. horizontal, single-cylinder wax tailing pumps operating on 135 lb. steam pressure and with a capacity of 40 g.p.m. each. Discharge pressure 275 lb. per sq. in.

2 The Whitlock Coil Pipe Co. 730-sq. ft. fuel oil heaters designed to heat 90 g.p.m. of fuel oil from 95 to 275 deg. F. with 4250 lb. per hr. of 135 lb. steam. Oil pressure drop through the heater 15 lb.

1 The Whitlock Coil Pipe Co. 280-sq. ft. acid sludge heater designed to heat 50,000 lb. per hr. from 190 to 225 deg. F. with 135 lb. steam.

Fuel Oil Tanks and Coke Bins..... .....Birmingham Tank Co.
Sludge and Tar Tanks..... .....R. D. Cole Mfg. Co.
Pump Lubricators.....Madison Kipp
Pump Governors ....The Fisher Governor Co.
Vacuum Drip Tank..... ....James Russell Boiler Works Co.

FEEDWATER SYSTEM EQUIPMENT

1 Foster Wheeler Corp. 430-sq. ft. blowdown heat exchanger designed to heat 754,000 lb. per hr. of treated water from 74 to 84 deg. F. with a water pressure drop of 6.25 lb. Uses 54,000 lb. per hr. of blowdown cooled from 222 deg. F. to 80 deg. F.

1 Foster Wheeler Corp. 2520-sq. ft., low-pressure closed heater with a normal water capacity of 750,000 lb. per hr. heated from 84 to 116 deg. F. Water pressure drop through the heater 4.5 lb. Uses exhaust steam from boiler feed pump turbines.

1 Foster Wheeler Corp. 7.5-c.f.m. steam jet air pump for removing noncondensable gases from low-pressure heater.

2 Worthington Pump & Mach. Corp. 2-stage, 60-g.p.m. at 60 lb. head heater drip pumps for draining above heaters.

2 Elliott Co. open tray type deaerating heaters with a capacity of 494,800 lb. of water per hr. each. Temperature water discharged 222 deg. F. Oxygen content 0.025 c.c. per liter. Uses fan turbine exhaust steam at 3 lb. pressure.

2 Elliott Co. 127-sq. ft. deaerator vent condensers with a capacity of 470,000 lb. per hr. Water pressure drop through the condenser of 4 ft. of water.

4 Ingersoll-Rand Co. class "HMT" 5-stage, 2400-r.p.m. centrifugal boiler feed pumps with a capacity of 1500 g.p.m. each against a discharge head of 795 lb. Driven by the Terry Steam Turbine Co., 135 lb., 438-deg. F., 930-hp., 2400-r.p.m. steam turbines.

Excess Pressure Regulator..... .....Smoot Engineering Corp.

1 Foster Wheeler Corp. 3675-sq. ft., high-pressure closed type heater designed to take steam at 135 lb. and deliver water at a temperature of 353 deg. F. Normal capacity 974,000 lb. per hr. Pressure drop through heater 3.75 lb.

Blowoff Flash Tanks..Cochrane Corp.
Blowoff Tank ....Houston Structural Steel Co.
Surge Tanks....Birmingham Tank Co.

2 Pomona Pump Co. 3000-g.p.m., 120-lb. discharge pressure, vertical centrifugal river water pumps, driven by 150-hp., 1160-r.p.m., 440-v. Westinghouse squirrel-cage induction motors.

3 Worthington Pump & Mach. Corp. 2000-g.p.m., 263-ft. head, horizontal centrifugal treated water pumps driven by 200-hp., 1800-r.p.m., 440-v. Allis-Chalmers induction motors.

1 Chicago Bridge & Iron Works 200,000-gal. elevated storage tank for treated water.

Water Treating System..... ....The Permutit Co.
Air Blowers...P. H. & F. M. Roots Co.
Backwash Pumps ..... The Goulds Pump Co., Lecourtenay Co., Inc.
Brine Pumps.....Taber Pump Co.
Chemical Scale.....Toledo Scale Co.

PIPING SYSTEM

Insulation .....Johns-Manville, Inc.
Steam Traps ....Armstrong Machine Works
Valves, Piping and Fittings..... American Brass Co., Andale Eng. Co., Armstrong Machine Wks., Atwood & Morrill Co., The Babcock & Wilcox Co., E. B. Badger & Sons Co., Baltimore Tube Co., Belknap Hardware & Mfg. Co., Cann & Saul Steel Co., Chapman Valve Mfg. Co., Chase Brass & Copper Co., Consolidated Ashcroft Hancock Co., Inc., E. J. Cox Engineering Co., Crane Co., Crosby Steam Gage & Valve Co., The Edward Valve & Mfg. Co., Erie Bolt & Nut Co., Fisher Governor Co., Golden Anderson Valve Specialty Co., The Lumsden & Van Stone Co., Lunkenheimer Co., Merco-Nordstrom Valve Co., Midwest Piping & Supply Co., Pittsburgh Piping & Equipment Co., Pittsburgh Valve, Foundry & Const. Co., Reading Steel Casting Co., Ross Heater & Mfg. Co., Inc., Ruggles-Klingemann Mfg. Co., Sarco Co., Inc., Schutte & Koerting Co., Walworth Company, Henry Vogt Mach. Co., Yarnall-Waring Co.

(List of equipment, including Turbines, Electrical Equipment and Instruments continued on next page.)

List of Equipment Continued

TURBINES

3 Westinghouse Elec. & Mfg. Co. 600-lb., 725-deg. F., 15,000-kw., 3600-r.p.m. turbo-generators operating against a back pressure of 141 lb. The generators are 15,000 kw., 80-per cent power factor, 13,800-v., 3-phase, 60-cycle machines with direct connected exciters rated at 90 kw., 250 v. d. c.
1 Westinghouse Elec. & Mfg. Co., 100-kw., 250-v., 4-pole, shunt-wound, exciter set consisting of an exciter generator, driven by a 135-lb., 438-deg. F., noncondensing turbine.
Generator Air Coolers.....The Griscom-Russell Co.
Generator Air Filters.....Power Equipment Co.
Auxiliary Oil Pumps.....Westinghouse Elec. & Mfg. Co.
Oil Pumps.....Viking Pump Co.
Oil Filters....S. F. Bowser & Co., Inc.
Oil Tank.....S. F. Bowser & Co., Inc.
Oil Purifier.The DeLaval Separator Co.
Purified Oil Receiving Tank.....Turbine Equipment Co.

ELECTRICAL EQUIPMENT

4 Westinghouse Elec. & Mfg. Co. 10,000 kv-a., 1 ph., 60-cycle, 3-winding 13.8/19/38-kv. power transformers.
2 Westinghouse Elec. & Mfg. Co. 1500-kv-a., 13,800/460-v., 3-ph., 60-cycle station transformers.
2 General Elec. Co. 150-kv-a., 1-ph., 460/115/230-v. lighting transformers.
19 Conduit Electrical Mfg. Co. 13.8-kv-a. oil circuit breakers.
99 The Champion Switch Co. 13.8-kv., 600 to 2000-amp. disconnecting switches.
2 Railway & Industrial Eng. Co. 73-kv., 600-amp. disconnecting switches.
56 The Champion Switch Co. 3-post, single-pole fuse and resistor mounting.
Bushings.....Ohio Brass Co.
Clocks.....Electric Time Co.
Compartment Doors.....F. R. Green Co., Loren W. Marsh Co.
Conduit, Fibre.....Fibre Conduit Co.
Conduit, Iron.....Central Tube Co.
Contactors.....General Electric Co.
Hardware.....National Hardware Co.
Inserts.....Concrete Steel Co.
Neutral Resistor.....Westinghouse Elec. & Mfg. Co.
Post Insulators.....The Champion Switch Co.
Reactors.....Westinghouse Elec. & Mfg. Co.
Storage Battery.....Philadelphia Storage Battery Co.
Switchboards.....Westinghouse Elec. & Mfg. Co.
Telephones.....S. H. Couch Co., Inc.
Transformers (current and potential).....General Elec. Co.
Wire and Cable.....American Steel & Wire Co., Anaconda Wire & Cable Co., The Kerite Wire & Cable Co., Phillips Wire Co., John A. Roebling's Sons Co., Safety Cable Co., Standard Underground Cable Co.
1 Worthington Pump & Machinery Corp. 301-c.f.m., 110-lb., 12 by 7½ by 9-in. horizontal duplex 2-stage air compressor driven through a short belt drive by a 75-hp., 1150-r.p.m., 440-v. General Electric double squirrel-cage induction motor.
Air Compressor Silencer.....The Maxim Silencer Co.
Unit Heaters.B. F. Sturtevant Co., Inc.
Ventilating Fans.....B. F. Sturtevant Co., Inc.
Rolling Steel Door.....Moeschl-Edwards Corrugating Co.
Grating and Stairs.....Blaw-Knox Co.
Station Crane.....Northern Engineering Works
Laboratory Equipment.Burrell Technical Supply Co., The Hagan Corp.
Sump pump.....Yeomans Bros. Co.

INSTRUMENTS

CO_2 Meters....C. J. Tagliabue Mfg. Co.
Draft Gages....Ellison Draft Gage Co.
Flow Meters.....American Meter Co., Bailey Meter Co.
Pressure Gages.....Bailey Meter Co., Consolidated Ashcroft, Hancock Co., Inc., Star Brass Mfg. Co.
Level Indicators.....Bailey Meter Co.
Manometers.....Consolidated Ashcroft Hancock Co., Inc.
Pyrometers.The Brown Instrument Co.
Thermometers.....Foxboro Co., Taylor Instrument Cos.
Thermometer Test Wells.....Consolidated Ashcroft Hancock Co., Inc.

Petroleum coke from the refinery forms about 16 per cent of the total fuel. Coke unloading, crushing, conveying and storing equipment is installed together with two ball mills which deliver pulverized coke to combination coke and gas burners, two of which are installed in the furnace of each of two boilers. The other burners are of the combination gas and oil type, equipped with the regular, as well as the special burner guns for handling the various fuels.

The high pressure steam piping system was simplified by arranging to put all the high pressure steam through the large turbines. A header made up of valves and fittings with branch lines to boilers and turbines makes up the entire system. Joints are of the welded type. No high pressure drain system is provided. The 140-lb. steam piping system is more extensive, serving all auxiliaries and carrying steam to the neighboring industry through two 24-in. welded steel lines with bends to allow for expansion.

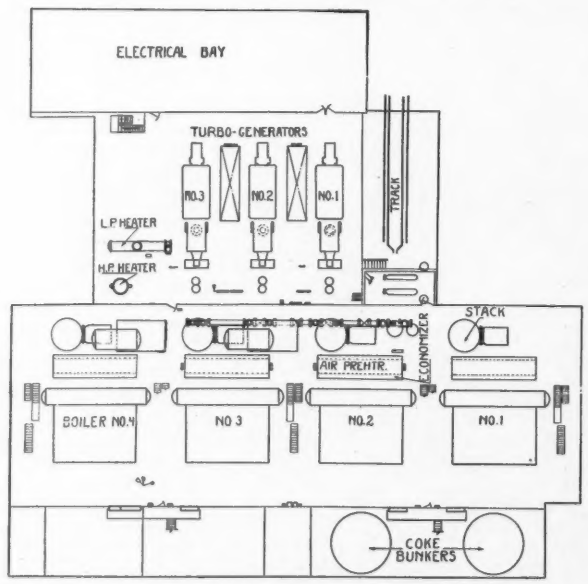


FIG. 6. PLAN OF THE STATION EQUIPMENT

An interesting arrangement to guard against excessive pressures in the turbine exhaust casing is provided. The motor operated 20-in. exhaust valves are arranged to open automatically when casing pressure rises to 140 lb. and to be closed by motor which is started manually only after the turbine throttle is closed. A relief valve and atmospheric exhaust line are provided on each turbine for starting purposes. Complete metering equipment is installed, an unusual feature being the use of orifice type mechanical steam flow meters in the steam lines to the industry with the orifices located in flanged joints between short sections of internally machined pipe.

The building is of red brick and steel construction with tile roof. A four-story electrical bay on the north side of the turbine room houses the switchboard and electrical equipment. The transformer station is of outdoor type.

EDISON MEDAL of the American Institute of Electrical Engineers has been awarded to Dr. Frank Conrad, Pittsburgh, Pa., for his contributions to radio broadcasting and short wave radio transmission.

Dr. Conrad was appointed a General Engineer of the Westinghouse organization in 1904 and was promoted to the position of Assistant Chief Engineer in 1921. In 1925, he was awarded the Morris Liebmann Memorial Prize of the Institute of Radio Engineers for his early work in connection with high-frequency transmission. He is a Fellow of the Institute of Radio Engineers, a member of the Society of Automotive Engineers, and a member of the American Association for the Advancement of Science. He received the honorary degree of Doctor of Science in 1928 from the University of Pittsburgh.

What Method Should be Used to Give a Fair

Comparison of Steam Station Performance

In the June 15 issue, Professor Christie proposed a new method of comparing steam station performance. This method involved the use of two constants and the capacity factor. This was discussed at length in the Aug. 15 issue from the stand-point of the general character of the load. In this issue Mr. Jeynes elaborates on this and offers answers to three questions raised in previous discussion.

By Paul H. Jeynes
Engineer, Public Service Elec. & Gas Co.
Newark, N. J.

INCREASING IMPORTANCE becomes attached to the simple relation between fuel consumption of a power station and its capacity factor, advanced by Professor Christie,* as it becomes more generally recognized that costs can often be estimated accurately by its use. Simple though the formula is, there are complications involved in its structure which easily lead to serious abuses. In this connection certain observations made by E. B. Ripley** are of outstanding importance. Explanation of the phenomena accurately reported but not accounted for by that author is desirable in order to add weight to his correct and fundamental conclusions.

The two-part formula is, he believes, "of great value for determination of the performance of any given steam station, as long as the general character of the load does not materially change." He further declares that its use is sometimes positively dangerous.

These conclusions are precisely worded and can not be emphasized too strongly. The latter is well demonstrated by exhibiting the difference between bogey fuel and formula fuel under certain conditions; also, by calling attention to the fact that the incremental fuel rate is not a constant. Some doubt is left in the mind of the reader, however, as to the trustworthiness of the method if it is subject to so many variables not readily explained. The following discussion provides the explanations for the three points raised by Mr. Ripley and attempts to defend the thesis that an exceedingly high percentage of accuracy is possible by intelligent application of the straight-line relation between cost and output.

Item 1. When pounds of coal for the period (day, week or month) are plotted against the output for the same period, a series of points are obtained which fall within a narrow band through which a straight line may be drawn; but Mr. Ripley has observed that the width of this band is approximately uniform where a large number of points are taken, whereas it might be anticipated that the scatter of points at the higher outputs would be greater, all of which suggests a larger percentage error for observations at low output, though he would be inclined to expect just the reverse.

The answer is that the scatter of points is only partially due to "errors." If daily results are plotted, starting and stopping errors may be fairly large, but their effect is less important than certain other considerations. Also, if no correction is made for injection temperatures when plotting points for intervals of less than a year, the effect of seasonal variations in vacuum will be evident; but this factor, as has been observed, fails to account for the uniformity of scatter at all outputs. Moreover, variations under the control of operators are unimportant, where the standard of operation is, as is usual, pretty consistent.

Available Equipment Is a Factor at Light Loads

For maximum output, except in special cases, only one combination of boilers and turbines is possible, the maximum number of both. For any smaller output, however, there are several possible combinations. It may be necessary, on account of maintenance outages during heavy load periods, to force what equipment is available to the utmost in order to generate half load; the same output may be generated at exceedingly low ratings on all of the equipment due to failure of prepared-for loads to materialize, or, due to occurrence of light load periods between times of heavy demand; or it may be generated at precisely the most economical rates on turbines and boilers when all goes well. Turbine availability may be noncoincident with corresponding boiler availability, causing uneconomical loadings on one or the other. Losses by reason of banked boilers often bear no relation whatever to the energy output. Each of these combinations results in a different fuel rate for the same load, thus accounting for a "scatter" of points which is a minimum at high capacity factors and increases for smaller outputs. This is half of the explanation; the other half is discussed below.

Item 2. "If a set of curves are plotted for a given station on a weekly or daily basis, the slopes of the two lines are not the same, nor is the intercept of the daily curve one-seventh of the intercept of the weekly curve."

This observation is accurate and Mr. Ripley's conclusion is correct though to a casual reader not very enlightening: "In the weekly figures, the Sunday low output is a part of the whole, whereas it is a point by itself in the daily figures." The following discussion is merely a simple and obvious verification of the principle.

Consider what the slope of the line represents. It is the additional fuel required for a certain additional output *having the same general characteristics;* or by inversion the decrease in fuel requirement for a certain decrease in output *having the same general characteristics.*

As a simple illustration, consider that the hourly fuel rate of a plant may be described as 2 lb. per kw-hr. at light loading and 1 lb. per kw-hr. under heavy loads and that a typical weekday consists of 12 hr. of heavy

*Power Plant Engineering, June 15, 1930, page 672.
**Power Plant Engineering, Aug. 15, 1930, page 912.

day load and 12 hr. of light night load. Suppose we experience an unusually light weekday load. The decrease we will assume to be all in the heavy day load period and for every kilowatt-hour decrease there is a decrease in fuel consumed of 1 lb. Several points plotted for such weekdays would give a slope of 1 lb. per kw-hr.

Sunday and Weekday Load Characteristics Differ

Now Sunday comes along, consisting not of two 12-hr. loading periods but of 20 hr. of light load and only 4 hr. of heavy load. Perhaps unusually light

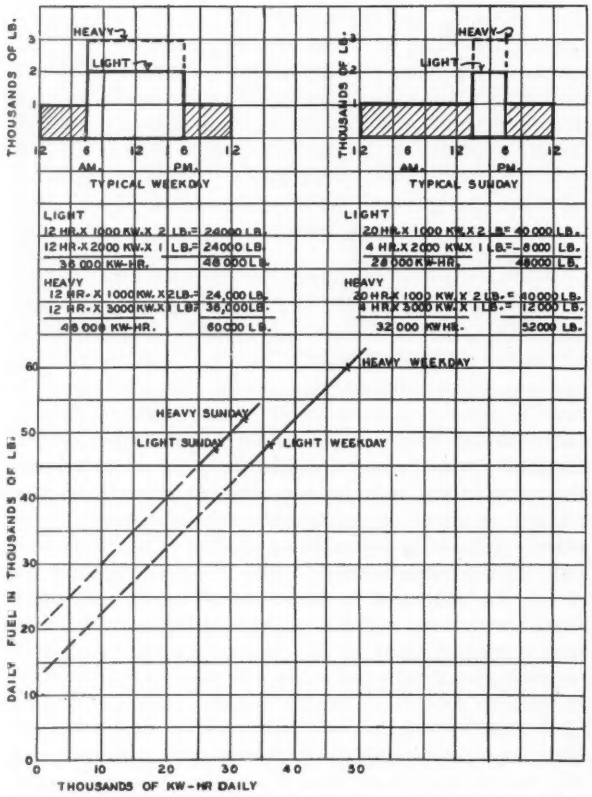

THOUSANDS OF LB.
HEAVY
LIGHT
12 6 12 6 12
AM. PM.
TYPICAL WEEKDAY
LIGHT
12 HR. X 1000 KW. X 2 LB. = 24000 LB.
12 HR. X 2000 KW. X 1 LB. = 24000 LB.
36 000 KW-HR. 48 000 LB.
HEAVY
12 HR. X 1000 KW. X 2 LB. = 24,000 LB.
12 HR. X 3000 KW. X 1 LB. = 36,000 LB.
48 000 KW-HR. 60 000 LB.
TYPICAL SUNDAY
LIGHT
20 HR. X 1000 KW. X 2 LB. = 40 000 LB.
4 HR. X 2000 KW. X 1 LB. = 8000 LB.
28 000 KW-HR. 48000 LB.
HEAVY
20 HR. X 1000 KW. X 2 LB. = 40000 LB.
4 HR. X 3000 KW. X 1 LB. = 12000 LB.
32 000 KW-HR. 52000 LB.
HEAVY WEEKDAY
HEAVY SUNDAY
LIGHT SUNDAY
LIGHT WEEKDAY
DAILY FUEL IN THOUSANDS OF LB.
THOUSANDS OF KW-HR DAILY

FIG. 1. SCATTER OF POINTS DUE TO A CHANGE IN LOAD CYCLE BUT WITH A CONSTANT INCREMENTAL FUEL RATE

Sunday loads are again due to loss of kilowatt-hours during the period of heavy loading or at the rate of 1 lb. per kw-hr. Again, plotting several points for various Sundays would give a slope of 1 lb. per kw-hr.

These points are plotted in Fig. 1. Can a single straight line be drawn through all four of them? Of course not. These loads on weekdays and on Sundays do not have the same general characteristics, i.e., the same daily cycle of heavy and light loads.

Now proceed to Fig. 2, where are plotted weekly results for the same station. A, B and C represent weeks of successively larger output. As in Fig. 1 the increase came consistently in the heavy load periods and at an incremental fuel rate of 1 lb. per kw-hr. An average line passes through the points because the loads do have the same general characteristics, i.e., the same weekly cycle of light and heavy loads.

Resuming for a moment the thought of Item 1, it is evident that at maximum outputs the minimum of variation in the loading cycle is possible, since the station is operating at maximum load most of the time. For moderate outputs, on the other hand, an infinite number of cycles are possible, with resultant scatter of plotted points.

Item 3. Input-output lines plotted for a station containing three identical turbines are not necessarily parallel to those for two of the machines but with a higher zero-load intercept, as Mr. Ripley found to be the case. Ripley's Fig. 2* shows some peculiarities which cannot be fully explained without more detailed knowledge of the loading cycle under the several conditions.

For instance, the curve for three-turbine operation does not coincide with the curve for the entire year for two and three turbines, particularly at light loads. Presumably all three turbines are never actually used for light loads, therefore it is assumed that the three-turbine curve is extended from points plotted within the actual three-turbine working range. If this is the case, the explanation is obvious. Each unit may be considered to have a steam consumption made up of a fixed amount required to supply zero-load losses, plus

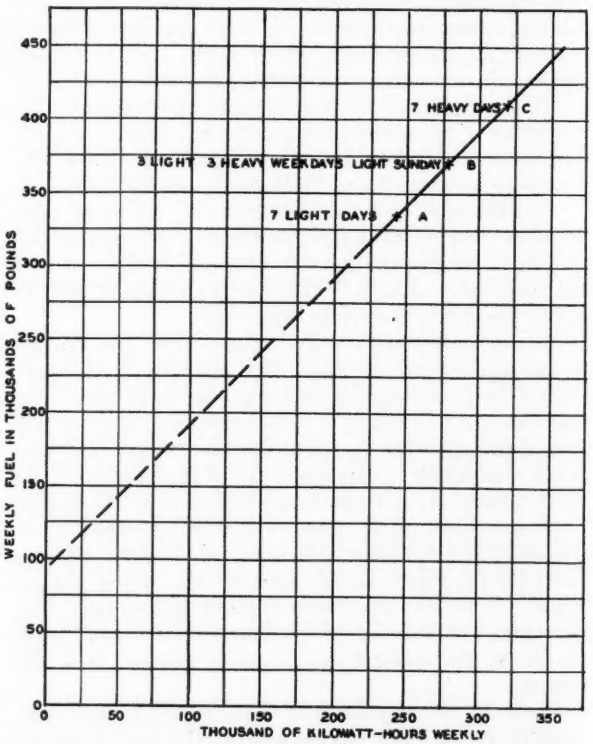

7 HEAVY DAYS C
3 LIGHT 3 HEAVY WEEKDAYS LIGHT SUNDAY B
7 LIGHT DAYS A
WEEKLY FUEL IN THOUSANDS OF POUNDS
THOUSAND OF KILOWATT-HOURS WEEKLY

FIG. 2. SCATTER OF POINTS DISAPPEARS WITH WEEKLY RESULTS BECAUSE OF SIMILAR CHARACTERISTICS

an additional requirement in some proportion to the output. To supply the fixed losses, three units naturally require more steam than two units. Incidentally, no-load fuel losses for the statin may not increase in the same proportion, since the boiler plant also has a characteristic input-output line which must be combined with that for the turbine room to express the plant's fuel rate.

Throughout the year, it appears from the curves referred to above that as weekly outputs increase the third

*Page 913 of Power Plant Engineering, Aug. 15, 1930.

unit is used more often, so that inevitably at maximum output the two lines coincide.

Errors Must Be Defined and Period of Time Specified

The whole trend of this discussion thus far is to dispel any impression that the simple straight-line relation between fuel consumption and capacity factor, while convenient, is more or less a coincidence and not of dependable accuracy. Perhaps, however, an objection to claims for accuracy may be based on the observation made in discussing Item 1 that the scatter of points is only partially due to errors; with the conclusion that therefore, the inherent uncertainty of this method is even greater than the magnitude of absolute errors. A qualified admission must be made as follows:

In the first place, what is meant by "errors"? Such errors as those of weighing the fuel or metering electrical output are soon discovered and corrected; over long periods the percentage error from such sources is very small. Seasonal variation in vacuum is sizable and unavoidable, but the same cycle is repeated year after year and the result, so far as annual data are concerned, is self-correcting. Deviations from perfect operation such as arise from gradually increasing dirtiness of heat transfer surfaces between cleaning periods, continual erosion of turbine blades until replacement is justified, failure to maintain precise distribution of load as scheduled, and so on, aggregate a constant "error" for any given loading cycle and the amount is not only small but predictable over periods of a year or longer. In brief, the absolute errors, which affect equally any conclusions drawn from existing records, are small; any additional scatter of points or apparent deviations from a straight line relation, such as discussed in Items 1 and 2, arise from predictable causes.

Accuracy Increases as Loading Schedules Are Closely Approached

On a carefully operated system the distribution of any given system load among the several stations can be confidently predicted years in advance except for such factors as non-scheduled outage or unforeseen transmission limitations. To be sure, it is sometimes necessary, in order to predict an instantaneous distribution, to know something more than simply the kilowatts of total load, perhaps the time of day or season of the year; but such controlling factors go through the same cycle from year to year. The scatter of points resulting from a variety of equipment combinations, of course, becomes smaller and more accurately predictable as the specified loading of stations and units is more closely approached.

Determination of the load cycle, which involves a knowledge of the peak to be carried but is vastly more important than that single factor, can be worked out in any desired amount of detail. It is not difficult to check formulas derived from past performance to discover whether they will fit anticipated loading conditions, or if necessary to develop new "synthetic" formulas by making appropriate changes as indicated by test data. Investigation of the load cycle simply to the extent of determining the percentage of total generation above and below the point at which the secondary steam valves begin to function, together with the relative increase of each class of kilowatt-hours (above or below) for an increase in annual capacity factor is often sufficient to keep the error within 3 per cent and provide a convenient and accurate tool for estimating costs far into the future. Even such dangerous investigations as rendering a decision between steam and hydro may be tackled with confidence.

COMPARISON OF CALCULATED AND ACTUAL FUEL RATES FOR FOUR STATIONS ON THE SAME SYSTEM

Station	1926 Annual Capacity Factor*	1926 Deviation of Formula Fuel from Reported Fuel	1927 Annual Capacity Factor*	1927 Deviation of Formula Fuel from Reported Fuel	1928 Annual Capacity Factor*	1928 Deviation of Formula Fuel from Reported Fuel	1929 Annual Capacity Factor*	1929 Deviation of Formula Fuel from Reported Fuel
A	.....	.....	47.9%	—0.2%	47.0%	—0.6%	54.0%	—2.7%
B	38.6%	1.7%	23.4%	0.5%	28.0%	2.4%	31.0%	2.3%
C	20.0%	—0.1%	17.3%	—0.4%	13.0%	3.6%	12.0%	—2.7%
D	50.1%	—0.1%	54.1%	—0.1%	59.0%	4.3%	16.0%	1.3%

*Based on gross generation.

This method of predicting long-term fuel consumption has been utilized for several years by Public Service Electric & Gas Co. in such problems as interconnection studies, which involve estimating future costs under a variety of loading conditions. The table sets forth the degree of accuracy attained over the past four years from use of the two-part formulas applicable to each of the four principal generating stations of this system. During this period, equipment changes at two of the plants necessitated corresponding adjustments in the formulas; in only one case was the change in character of load sufficiently great to require a modification.

It has been found as a general rule that annual capacity factors from 40 to 60 per cent involve load cycles sufficiently alike from year to year so that one formula will usually apply without adjustment throughout the range. Another such range is from about 15 to 40 per cent and again for outputs in excess of 60 per cent capacity factor. Below 15 per cent adjustments are increasingly important. It is customary to set up several variations of the formula for each class of service at these low outputs, such as seasonal peak operation, limited base load generation and hot standby. Great precision is still possible, though in practice the extra labor of obtaining it is seldom justified because the quantities involved are such a small component of the system total.

Embrittlement and Protection of Steam Boilers

FAILURES MAY RESULT FROM A NUMBER OF FACTORS WHICH ARE OUTLINED. EMBRITTLEMENT FAILURES ARE DISTINCTIVE AND REQUIRE DISTINCTIVE TREATMENT. BY FREDERICK G. STRAUB*

EXAMINATION of the records of power plant operation reveals many cases of disastrous boiler explosions. In attempting to explain failure of boiler steel, the following factors must all be given due consideration: Material; workmanship; conditions of operation; nature of feedwater used. A steel having the wrong chemical composition or one receiving improper heat treatment will, in many instances, fail in service but it is easy to check cases of this kind by chemical analysis, physical tests and microscopic examinations.

Tests made on steel taken from boilers which have been embrittled show that in general they meet the

FIG. 1. AREAS IN WHICH BOILERS USING WELL WATER HAVE BEEN EMBRITTLED

chemical specification for standard boiler steel; show no marked deviation from the specification requirements for boiler plate steel; had good crystal structure with the carbon well distributed in even-grained pearlitic form with no indications of excessive cold work present in the majority of cases.

Questions of workmanship are always open to debate. No riveted boiler is made with absolutely leak-proof, perfectly-fitting seams free from localized high stresses. All the evidence gained from a complete and unbiased examination of embrittled boilers points to the conclusion that poor workmanship alone never caused any boiler to become embrittled. Conditions of operation of a boiler may be a large contributing factor in causing trouble. The effects of operating at high rating; of hot gases in contact with the metal parts of the boilers; of frequent hydrostatic tests; of excessive calking of leaky seams; of the presence of high operating stresses at high temperatures over prolonged periods of time are all to be considered in trying to ascertain the causes of embrittlement. The files of the investigation contain numerous reports of instances of embrittlement which indicate that no one factor of operation or boiler design is common to the many cases of failure.

*Special Research Assistant Professor in Chemical Engineering, University of Illinois. This article is taken from Part II, Bulletin 216, of the Engineering Experiment Station of the University at Urbana, Ill., reporting an investigation conducted in coöperation with the Utilities Research Commission.

FEEDWATER APPARENTLY THE ONLY COMMON FACTOR

On examining the mass of data collected from cases of embrittled boilers it could be clearly seen that the type of feedwater used in embrittled boilers was apparently a common factor. Analysis of feedwater used in such cases disclosed that sodium carbonate was always present in considerable quantity while the sulphate content was much lower. The boiler waters showed the presence of a high caustic alkalinity with a correspondingly small sulphate content.

In order to study the matter of embrittlement it was deemed essential in the first place to develop some means of recognizing cases of embrittlement which would be reliable without question and distinctly to differentiate such phenomena from other similar or related conditions. This led directly to a study of the cracking of rolled or fabricated plate. Studies along this line have revealed the fact that three types of cracks may occur as follows: corrosion cracks; fatigue crack; embrittlement cracks. Each one of these three types is distinctive and can be definitely differentiated from the other by micrographic analysis. These characteristics may be briefly described as follows:

CORROSION CRACKS

Corrosion cracks, as the name implies, are due to direct corrosion of the metal. This follows in principle the well-known phenomenon where parts of a metal differ in composition or physical properties from other parts, due to strains, or density, or impurities. In the presence of an electrolyte, by reason of the fact that one portion of the metal is electropositive to another so a galvanic circuit is set up, there is started a solution action on the positive side and a corrosion area is developed. These corrosion areas or cracks in the case of metal under stress will follow the lines of stress as would naturally be expected.

Since the solvent action is accentuated, or occurs in the presence of that type of ionization wherein the hydrogen ions predominate, one would expect to find such examples of corrosion in the presence of electrolytes, as nitrates, chlorides, or sulphates. Such corrosion phenomena would be checked or inhibited by the presence of hydroxyl ions or that condition where an alkaline state exists. This in itself will explain why one would not expect to find corrosion cracks in boilers using waters which are alkaline in character. Such a crack is shown by the microphotograph, Fig. 2A, but a study of such corrosion does not necessarily require a micrographic analysis of the structure of the corroded surface. The direction of the cracks follows the lines

of stress without regard to grain areas, the cracks proceeding across the grains, disregarding grain boundaries.

Fatigue Cracks

Development of cracks due to stress alone furnishes interesting illustrative material in the study of metal cracks. It seems that, as failure is approached, in metals placed under reverse stress, cracks develop, which upon micrographic study reveal a positive characteristic serving as a ready means of identification. By examination of a few of this type of specimens, it is obvious that the cracks which have been started as a result of fatigue do not respect the fact of grain structure in the metal but follow a course quite independent of grain boundaries

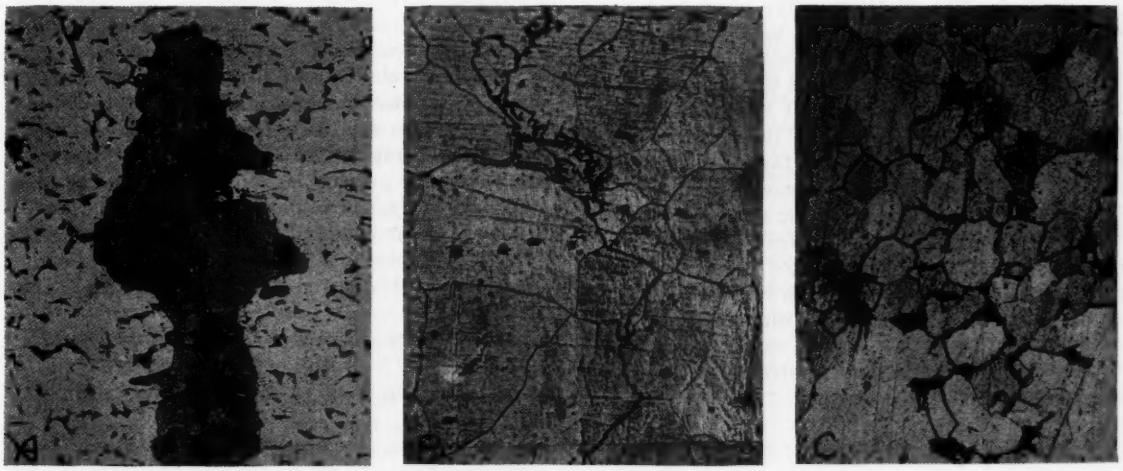


FIG. 2. MICROGRAPHS SHOWING A, CORROSION CRACKS (X100); B, FATIGUE CRACKS (X350); C, EMBRITTLE-CRACKS (X250)

hence they are described as cross-granular as opposed to inter-granular in their directional development as shown by Fig. 2B.

Embrittlement Cracks

It is now possible to differentiate those cracks which accompany embrittlement from either of the types already described for the reason that a micrographic study shows one distinctive characteristic of this type of crack. By reference to the micrographs of embrittlement cracks, especially when the surface is etched in such a manner as to bring out clearly the grain boundaries, it is evident that these embrittlement cracks follow grain boundaries as indicated in Fig. 2C.

Salient features which are characteristic of embrittlement may be more fully understood after a brief survey of typical examples taken from numerous cases of failures. Characteristics of these cracks may be summarized as follows: The cracks do not follow what is generally considered the line of maximum stress; they start on what is termed the dry side of the plate; they run, in general, from one rivet hole to another, though they often run past each other, leaving islands of plate; they are irregular in direction; they never extend into the body of the plate beyond the lap of the seam; there is no elongation of the plate; where extreme action has occurred rivet heads crack off or are easily dislodged by a slight blow of the hammer.

A summary of conditions relating to the location of cracks in the boiler may be given as follows: They occur in seams under tension; they are found at places where the highest localized stresses might be assumed to occur; they occur in plates having practically perfect chemical composition and physical properties, as well as in plates of inferior make.

Failures Occurred at Pressures from 30 to 425 Lb.

During the interval between January, 1925, and January, 1930, 25 new instances of embrittlement involving some 60 boilers were brought to the attention of the investigators. At least one million dollars was involved in replacing or repairing these boilers. Property damage resulting from one explosion resulted in a loss of almost one-quarter of a million dollars, as well as the loss of one life.

These cases of embrittlement occurred on boilers operating with pressures as low as 30 lb. per sq. in. and as high as 425 lb. per sq. in., and on different types of boilers, thus illustrating further that the trouble is not confined to any one make or design of boiler. The cracks were found not only in riveted areas or tube ends but occurred at random in practically any seam in the boiler. Samples of steel from a large number of these cracked boilers were analyzed and tested and no marked deviation from the original mill reports was evident. This tended to confirm the opinion previously stated that embrittlement is not confined to poor steel.

Results that have been obtained from the assembling of information obtained from almost 400 cracked boilers may be briefly summarized as follows:

(1) Neither the design nor the workmanship appear to be the fundamental cause of the cracking. This conclusion is drawn since boilers made in practically every large boiler shop in the United States have cracked and at the same time standard boilers made over a period of 30 yr. have cracked, the newer ones as fast as the older ones.

(2) No fault can be found with the material of the boiler plate, since the quality was fully up to specification requirements in the greater number of cases. Boiler steel made in 1900 cracked as rapidly as boiler

steel made in 1925. Plate made in practically every large steel mill has cracked.

(3) The operation of the boilers has in general been satisfactory since other boilers have operated under similar conditions for years without encountering this difficulty.

(4) A caustic condition of the boiler water, with a low sulphate content, was found in all cases of embrittled boilers.

(5) Increasing the sulphate content has been found to be effective in stopping or inhibiting embrittlement cracking in steam boilers.

When this information is given thorough consideration, it is realized that there are two factors common to all embrittled boilers, namely, caustic boiler water and highly stressed areas adjacent to the rivets and tubes. The cracking takes place only in the areas which are highly stressed and where concentration of boiler water might take place. It is only logical to conclude that the cracking results from the action of the caustic concentration in the crevices attacking the highly stressed metal. Any condition which will favor either the concentration of solution or the over-stressing of the metal will naturally tend to accelerate the cracking.

Since the cause of embrittlement cracking is undoubtedly the action of concentrated caustic on highly stressed metal, one would expect to be able to stop the cracking by either one of the following methods: Prevent the caustic boiler water from concentrating; eliminate the highly stressed areas; neutralize or inhibit the action of the concentrated caustic.

Calking

All boilers which have cracked have had the seams calked outside, or both outside and inside. This brings about a condition which is extremely favorable to concentration of the boiler water.

If the boilers are so constructed that the seams and rivets are all properly calked on the inside and left uncalked on the outside, the seepage of the boiler water into the riveted areas will be prevented. At the same time, the tubes should be so rolled that they are tightest at point of contact with the inside of the drum or header. If any boiler water should pass the inside calking, the outside, being uncalked, will leave an opening for this water to go through and a free leak will result. Concentration is not so likely to take place. When the leak is discovered, the inside and not the outside should be calked to stop the leak.

In some installations at higher pressure, the use of seamless drums is to be recommended since drums made in this manner will not have any seams. The highly stressed areas where boiler water may concentrate are practically eliminated. The tube ends are the only sections left where the cracking might occur and if these are properly rolled the possibility of trouble here is reduced to a minimum.

Improved methods of boiler design and construction will undoubtedly go a long way toward decreasing the possibility of the occurrence of embrittlement but at present they are only applicable to boilers for higher pressures and large installations. In smaller boilers built for lower pressures, the grade of workmanship necessary for the making of these improved seams and seamless drums cannot be used without a reasonable cost being exceeded. Furthermore, this would mean that the plant using a water not potentially embrittling would have to pay for protection necessary only for plants in which there is a possibility of embrittlement.

Another fact to be considered is that boilers now in use cannot be changed but should operate their rated lifetime. The only means of protecting old boilers and making the new ones doubly safe against embrittlement is by the treatment of the feedwater so as to counteract the embrittling effect of the caustic in the boiler water.

Hardness in boiler feedwater can be considered roughly under two heads, carbonate hardness and sulphate hardness. In carbonate hardness, the carbonates of magnesium or calcium are present in excess and only a small amount of the corresponding sulphates is found. This type of hardness has commonly been termed temporary hardness, since it decreases on heating. The sulphates of calcium and magnesium are changed but little on heating and hardness due to the presence of these sulphates has been termed permanent hardness. In some natural waters in the United States, sodium bicarbonate is present in appreciable amounts and almost invariably the sulphate content is relatively low. When the water is heated in the boiler the sodium bicarbonate breaks down to give the carbonate which in turn decomposes to give sodium hydroxide and carbon dioxide as:

$$H_2O + Na_2CO_3 = 2\ NaOH + CO_2$$

Water + sodium carbonate = sodium hydroxide + carbon dioxide.

Extent of the decomposition of the carbonate depends upon the temperature or steam pressure and the partial pressure of the carbon dioxide. In a boiler, the steam carries away the carbon dioxide favoring the formation of the hydrate. Boilers have been found where over 90 per cent of the sodium carbonate has been changed to sodium hydroxide.

Sodium hydroxide is found in nearly all boiler water since soda ash is a common boiler compound but the percentage occurring is not nearly so high as that found in embrittled boilers and, furthermore, sulphates are generally present also in large amounts. If calcium or magnesium sulphates are present soda ash is added to form the less soluble carbonates and soluble sodium sulphate as:

$$Na_2CO_3 + CaSO_4 = Na_2SO_4 + CaCO_2$$

Sodium carbonate + calcium sulphate = sodium sulphate + calcium carbonate.

Sodium sulphate is increased so that the addition of an excessive amount of soda ash would be necessary to bring about an excess over the sulphate in normal permanent hardness. A water containing small amounts of sulphates, however, could readily be changed to one in which the sodium hydroxide is in excess by soda ash treatment and such types of water have been found in embrittled boilers.

Sodium carbonate may, therefore, be present in the feedwater in excess of the sulphate as a result of either one of two causes. First, naturally, in a well water having the sodium carbonate present, and second, as the result of water treatment. The addition of an excess of soda ash will produce such a water, or it may result from the use of the zeolite process of softening. In this process, the softening is accomplished by means of either a mineral or an artificial zeolite. The bicarbonates of

calcium and magnesium are converted to bicarbonate of soda and the sulphates of calcium and magnesium to sodium sulphate, thus furnishing a water with so-called zero hardness. The zeolite is rejuvenated by treating with sodium chloride solution. This system, when used on a water having a lower sulphate than carbonate hardness, will produce a water in which the carbonate of soda content will predominate over the sulphate content, thus resembling the feedwaters used in boilers that have encountered embrittlement.

Areas of Dangerous Well Waters Can Be Isolated

Districts in the United States where embrittlement has occurred in boilers using well waters containing sodium bicarbonate can readily be isolated. The map in Fig. 1 shows the location of these districts. Much effort has recently been directed toward treating these natural waters so as to overcome the effect of the excess of sodium bicarbonate and cases of embrittlement with these waters are apparently decreasing in number. The increase in the use of water treatment on surface waters low in sulphates has brought about an increase in the use of the soda ash and zeolite systems of softening. Naturally, waters having too high a sodium carbonate content as a result of either of these systems of water treatment cannot be isolated in any particular districts, since low sulphate surface waters occur in practically all sections of the country. As a result of this trend in water treatment the number of cases of embrittlement resulting from the use of these types of softened waters is increasing.

Analysis of earlier data collected showed that boilers having high caustic alkalinity in the absence of sulphate cracked while boilers having high sulphate and low alkalinity did not crack and that where boilers cracked and the water was changed to increase the sulphate cracking did not occur again. On the strength of this the A.S.M.E. Boiler Code committee in 1925 recommended maintaining a ratio of sodium sulphate to sodium carbonate ranging from 3 to 1 for pressures up to 150 lb. gage to 3 to 1 for pressures of 250 lb. gage and over.

Recent investigations show that in general the 3 to 1 ratio is sufficient for practically all boiler pressures but that the 1 to 1 ratio is low and should be increased to at least 2 to 1.* They also show that the amount of sodium sulphate necessary in the boiler water is dependent on the amount of sodium hydroxide formed, as well as the amount of sodium carbonate left undecomposed. The proper method of water treatment to be used to prevent embrittlement depends entirely upon the type of feedwater and the boiler water. Figure 3 shows a curve which may be used in determining the boiler water conditions necessary to prevent embrittlement. A systematic analysis should be made of the actual boiler waters over a period of time determining the sodium hydroxide, sodium carbonate and sodium sulphate.

Ratios of $\frac{Na_2CO_3}{NaOH}$ and $\frac{Na_2SO_4}{NaOH}$ should be calculated and plotted. If the plotted values fall well above the curve shown in Fig. 3, it will indicate that the water is not embrittling in nature and the system of water treatment in use could be continued. Of course if scale, dirty steam, or other distressing conditions are evident, the water treatment should be changed so as to eliminate these conditions. If, however, the plotted values fall close to or below the curve, some method of water treatment should be inaugurated which will do one of two things: (1) increase the ratio of $\frac{Na_2CO_3}{NaOH}$ or (2) increase the ratio of $\frac{Na_2SO_4}{NaOH}$. Which one of these ratios may be changed depends entirely upon the conditions of the plant under consideration. The direct addition of sulphates, or the use of sulphuric acid to increase the sulphate content, should be begun only under the advice of a chemical engineer familiar with this phase of water treatment and frequent analyses should be made to see that the treatment is correct.

If the conditions of operation are such that it becomes practically impossible to increase the sulphate to hydrate ratio so as to be protective, then the use of another method of preventing embrittlement should be resorted to. The laboratory work has shown that phosphate may be effective in preventing embrittlement if properly used. It should be realized that phosphate, if not used under a definite control, might not only be useless but also dangerous.

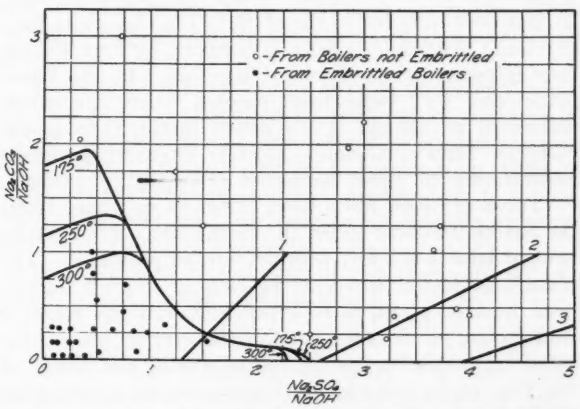


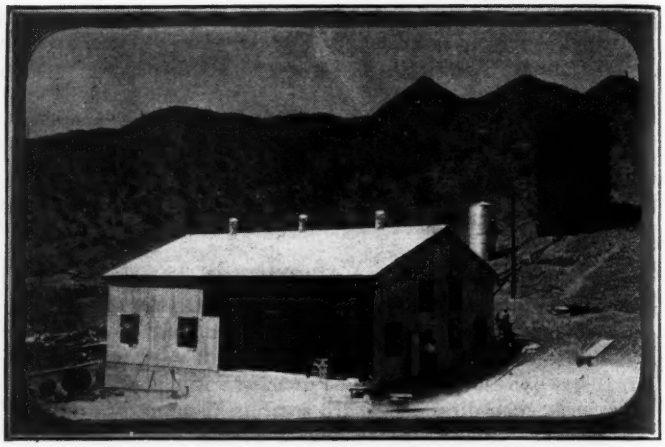
FIG. 3. RATIOS NECESSARY TO PREVENT EMBRITTLEMENT

More Care Needed with Evaporated Make-up

In power plants using evaporators entirely for make-up and having no chemical treatment whatever, the question of proper ratio involves the accurate determination of the sodium hydroxide and sodium carbonate. Often the sodium solubility of calcium carbonate and magnesium hydroxide becomes appreciable in determining the total alkalinity. Methods of analyses which allow for the calcium carbonate and magnesium hydroxide should be used in determining the sodium hydroxide and sodium carbonate which may be used for determining the ratios. If this is done, many plants of this nature which are now apparently not meeting the recommended ratio will be found to be in the protected area as far as embrittlement is concerned.

*See Recent Developments in Embrittlement Research by Frederick G. Straub, p. 686, June 15, 1930 issue of Power Plant Engineering.

Diesel Drive For Concentrator at Arizona Mine



REFINEMENTS OF EQUIPMENT INCLUDING AIR AND OIL FILTERS AND LUBRICANT RECLAIMERS CHARACTERIZE DIESEL PLANT WHICH IS SIMPLY HOUSED BECAUSE OF GEOGRAPHICAL LOCATION

POWER FOR THE new 400-t. concentrator which has been installed at the plant of the Christmas Copper Co., Christmas, Arizona, is supplied by four 450-hp. four-cylinder, four-cycle, solid-injection, Chicago Pneumatic Tool Co., Benz-Diesel engines which are direct connected to 300-kw. at 0.8 power factor, three-phase, 60-cycle, 2300-v., General Electric alternating-current generators with direct connected 12-kw., 125-v. exciters.

Three of these units were installed in June, 1929; the fourth unit was added in April, 1930. The average present load is 625 kw. with 900 kw. as peak load. The plant load factor, which is the ratio of average load to peak load of plant, is 69.4 per cent and the machine load factor, which is the ratio of the average load to the rated capacity of a specific engine during the period of one year or, in this case during the period of operation of the last installed engine, is 76 per cent, the average load per engine being 208.33 kw. and the capacity, at the elevation of the plant which is 215C ft. above sea level, is 272 kw.

California crude oil having a gravity of 24 deg. Baumé, a heating value of 1,406,000 B.t.u. per gal., and furnishing 10.7 kw. per gal. is used as fuel. The temperature is never so low in this locality that heating of the oil is required to pump it.

FIG. 1. REAR VIEW OF ENGINES SHOWING PUMP LOCATION AND ACCESS TO DAY STORAGE TANK UNDER ENGINE ROOM FLOOR

Analysis of the fuel oil used discloses the following:

Gravity, deg. Baumé at 60 deg. F	24
Specific gravity at 60 deg. F	0.91
Weight per U. S. gallon, lb	7.57
Viscosity, at 77 deg. F., approx. Englers	0.4
Percentage asphaltum, approx	25
Calorific value, B.t.u. per lb. approx	19,000
Sulphur content, approx. per cent	1
Flash point, closed cup, deg. F	150
Water and non-petroleum sediment, per cent approx.	1

Storage facilities consist of three 15,000-gal. corrugated galvanized iron tanks having a common header which enables the oil to be pumped into or drawn from each tank, at will, through valve connections, a 1½ by 1½-in., 35-g.p.m. Viking pump being used to pump the fuel oil from the cars to the storage tanks.

A 500-gal. day storage tank is located under the floor of the power house. This is kept full by a float switch which operates a 1¼ by 1¼-in. Viking motor-driven pump. The fuel oil is then pumped to 5-gal. tanks, with which each engine is provided, by individual plunger pumps attached directly to the engine cam shaft. From these tanks, the oil flows by gravity to the suction fuel injection pumps from which the portion which is not consumed is bypassed and returned to the day tank.

WELL WATER USED FOR COOLING PUMPED BY AIR LIFT

Cooling water is secured from two deep wells which are operated by an air lift which discharges into a sump. The water is then pumped to the water-storage tank by a motor-driven, float-switch controlled, centrifugal pump. This tank, which is located at an elevation of 90 ft. above the power plant, is 6 ft. in diameter by 20 ft. high and has a capacity of 4200 gal. The air compressor used is an Ingersoll-Rand, size 5 by 5-in., 50-c.p.m. compressor, direct connected to a Westinghouse 15-hp., 870-r.p.m., 440-v. induction motor.

Water cooling is accomplished by a 35-ft. Braun cooling tower constructed of redwood and furnished with copper hardware. It is provided with ten 12 by

18-ft. trays and a wooden distribution box and channels having valves to distribute the flow. Slat bottoms and sides make possible intimate mixture of the air and water without undue loss of water from spray.

Jacket Water Temperature Raised 20 to 30 Deg. F.

Cooling water from the sump is pumped to the storage tank by a Cameron, 4-in., three-stage, 314-g.p.m. centrifugal pump direct connected to a General Electric 440-v., 1170-r.p.m., 20-hp. induction motor. The motor is pumped from the tower pan through the engine jackets by two Byron-Jackson 3 by 10-in., 270-g.p.m., 70-ft. head, 1750-r.p.m. centrifugal pumps direct connected to General Electric 10-hp., 400-v., 1740-r.p.m. induction motors and one Byron-Jackson 375-g.p.m., 125-ft. head, 3510-r.p.m. centrifugal pump direct connected to a General Electric, 15-hp., 440-v., 3510-r.p.m. induction motor which is equipped with ball bearings. Cooling water enters the engine jackets at from 68 to 70 deg. F. and leaves them at from 90 to 110 deg. according to the load.

35 Grain per Gal. Hard Water Softened by Zeolite System

Make-up cooling water, which amounts to about 8000 gal. per 24 hr., is supplied to the tower pan from the storage tank after it has passed by gravity through the water softener which is of the zeolite type built by the Permutit Co. The zeolite is washed and regenerated with salt brine after 4300 gal. of 35-grain water has been run through the softener at an approximate rate of 13 g.p.m.

Each regeneration requires 96 lb. of salt. After a prolonged dry spell the hardness of the raw water drops to about 25 g.p. gal. at which time 7500 gal. of water may be treated on a 96-lb. charge.

Analysis of the raw water gives the following mineral content:

Mineral	Gr. per gal.
Silica	0.955
Oxides of iron and aluminum	0.093
Carbonate of lime	3.950
Sulphate of lime	25.292
Carbonate of magnesia	8.370
Sodium and potassium sulphates	7.469
Sodium and potassium chlorides	30.600
Sodium and potassium nitrates	Trace
Loss, etc.	0.359
Total mineral solids	77.088
Organic matter	Trace
Total incrusting solids	38.660
Total non-incrusting solids	38.428

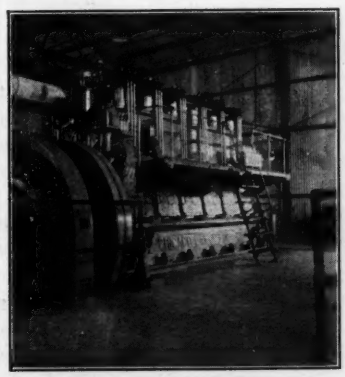


FIG. 2. FRONT VIEW OF ONE OF THE ENGINES SHOWING 5-GAL. FUEL TANK ATTACHED TO ENGINE AT THE SAME ELEVATION AS THE CYLINDER

Water contains a little more than 77 gr. of mineral matter and a trace of organic matter per U. S. gallon of 231 cu. in.

Air Filters Furnish Clean Air

Each engine unit is provided with two Midwest air filters which are located outside of the power house. Headers, running direct from the air intake manifold connect the filters. Cleaning the filter cells is accomplished by washing them in a solution of soft water and sal soda after which they are recharged by treatment with viscosine.

The exhaust manifold is water jacketed for cooling at the engine. The exhaust pipe is insulated with asbestos pipe covering from the engine to the wall of the building and the exhaust muffler is of the standard cast-iron pot type.

Forced Feed Lubrication

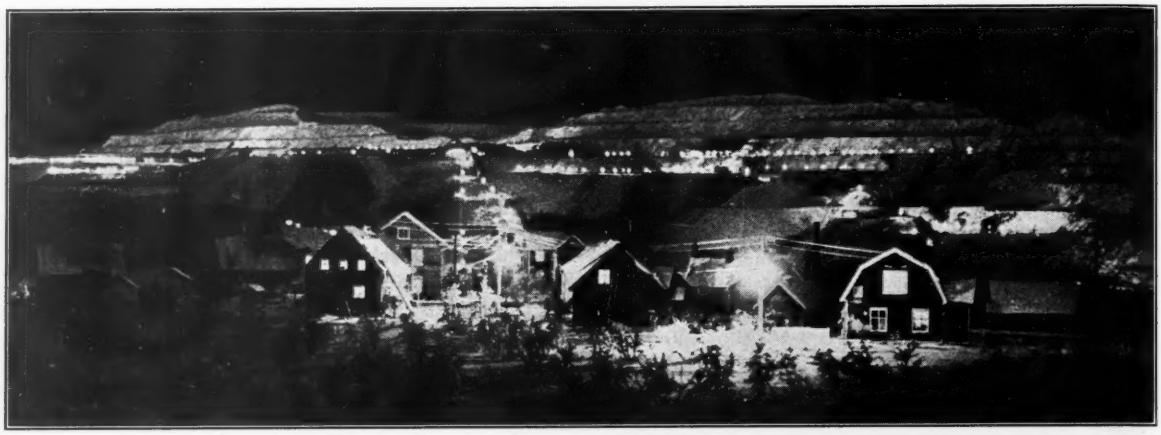
Forced-feed lubrication is used for all bearings and timed forced feed for the pistons. Each engine is equipped with a De Laval horizontal centrifugal oil clarifier. A De Laval centrifugal batch reclaimer is also installed in the plant. D.T.E. extra heavy oil is used and 2000 kw-hr. are generated per gallon of lubricating oil.

Starting air is furnished by two 4½ and 2 by 4½-in., Gardner-Rix, two-stage, 500-lb. compressors, one motor driven; the other driven by a New Way air-cooled gasoline engine. Four 18 by 69-in. air-starting bottles, which are kept charged to 400 lb. pressure, are installed. Under this pressure there is sufficient capacity to start two engines without recharging.

H. A. Rossell is manager of the plant and C. A. Bilson is power plant superintendent.

Matthew S. Sloan, president of The New York Edison System, has announced that two new boiler units, which, with the building in which they are housed, coal pulverizing mills, superheaters, economizers, air heaters and other auxiliaries, were built at a cost of $5,000,000, have just been put into service by The United Electric Light and Power Co. at its Hell Gate Generating Station. These two boilers, manufactured by the Babcock & Wilcox Co., supply steam to drive one of the 160,000-kw. turbo-generators installed some time ago. Each boiler has a nominal rating of 800,000 lb. of steam an hour at a temperature of 725 deg. F. and 275 lb. pressure. They have many new features of design. All fans, mills, feeders and dampers are controlled from a central operating board, centralizing the control to an extent never before attempted, it is stated. At maximum capacity there is burned in the furnace for each boiler about 100,000 lb. of coal an hour and the output exceeds 1,000,000 lb. of steam an hour. Furnace ash is discharged periodically in molten form.

To transmit power without slipping and to absorb shock loads, belts need a surface which will grip the pulleys well, also considerable elasticity. The best quality leather to meet these requirements is cut from that part of the hide back of the shoulders and close to the backbone.



White Lights North of The Arctic Circle

A Description of the World's Northernmost Power Station. By Harry Chapin Plummer

MANY MILES NORTH of the arctic circle in Lapland, the Swedish government has built a hydroelectric generating station which is said to be the world's northernmost large power station. This plant, which is located at Porjus on the Lule River, is not only in full operation but it is making good financially. It is providing power, light and heat for ore mining operations on a large scale, for not one, but many widely separated towns and villages within an area that hitherto sustained no human habitation, no vegetable life and only the reindeer as fauna. Yet, more important, it is the source of power for a modern electric railway system that connects the iron ore mines with ports on the nearby Baltic Sea and on the more distant North Atlantic in Norway and provides a twice daily passenger train service each way with Stockholm, the Swedish capital. As a lighting plant, this station is of considerable importance for it serves to dispel the gloom of the month-long arctic night which prevails in this forbidding territory.

Lapland is a country of rushing, roaring rivers and the Lule River provides more than half the 650,000 hp. which these streams are capable of generating and this, in turn, is 65 per cent of all of Sweden's water power. So the Porjus Falls on the Lule were chosen for a first hydroelectric development in Sweden's most northern possession, the power being primarily needed for the electrification of the railroad from Kiruna, seat of the mining industry, to the aforementioned seaports.

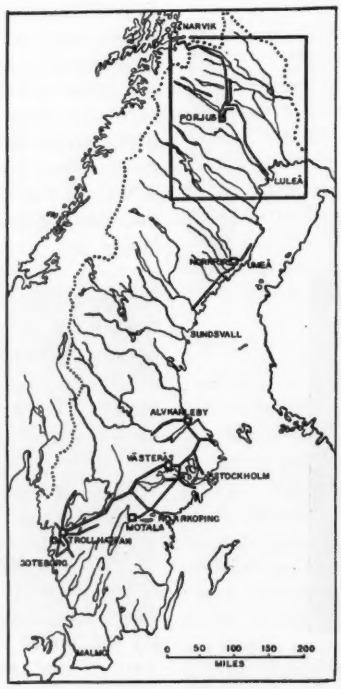


FIG. 1. GENERAL MAP

The geographical position of the falls makes it possible to transmit energy economically to the iron mines at Gellivare and Kiruna and the great volume of power available at Porjus also renders it possible to deliver appreciable quantities of cheap energy to new industries growing up in the neighborhood. A distinct reason for taking Porjus as a starting point for hydraulic development in this region was that, according to preliminary investigations, a complete utilization of the water power of the Lule Alv, to give the river its complete name, would necessitate a comprehensive hydraulic regulation of the entire river system and that the harnessing of the Porjus Falls would advantageously re-act upon the other falls in the river, increasing their value and facilitating a final development.

The Lule Alv is Northern Sweden's most important stream. From Porjus, which is situated at the point where the river leaves Stora Lulejaure, and to the Baltic Sea, the water drops about 1115 ft., forming a number of waterfalls and rapids more or less susceptible of development.

Originally the waterflow varied from 1410 cu. ft. per second up to 53,000 cu. ft. per second in flood season, but after completed regulation of the upper lakes the minimum flow should be brought up to about 7000 cu. ft. per sec.

Hydraulic construction was begun at Porjus in 1910 and in 1914 the first generating set was taken into service. The installed generating capacity of the present plant is 58,500 kw., part of this being represented by

single-phase, part by three-phase generators. The single-phase energy is delivered to the aforementiond railroad at 80,000 v. over a 150-mi. line. Three-phase energy is transmitted at 70,000 v. to the iron mines at Kiruna and Gellivare, 87 miles distant, while electro-chemical and electro-thermal industries in the neighborhood of the power station are supplied at 10,000 v.

Just below the lake Stora Lulejaure the river broadens out, forming a pond, which is called Stora Porjussel. At the point where the river leaves this pond a dam has been erected whereby the water surface is maintained at about 32 ft. above its old level. This fall-height, together with that of Porjus Falls, provides a total head varying from 180 ft. to 192 ft., according to the discharge of the river. The forebay water capacity permits the establishment of a one-week hydraulic regulation period.

The dam is about 4100 ft. long, consisting mainly of earth, with a water-tight core of reënforced concrete on rock bottom, and with a ballasting stone-wall on the downstream side. Surplus water is discharged over 650 ft. of Ambursen-type spillway, built in two sections. A 40-ft. opening with roller gate leads to a timber chute.

From the water intake an excavated rock basin on the east river bank, an intake tunnel runs 1700 ft. to a roof-covered distribution reservoir. The reservoir contains 5 chambers, which can be separately cut off by sluice-gates. From these chambers penstocks run, each built into a 168 ft. deep vertical shaft, to the 5 first generator sets. The sixth unit is provisionally fed by a similar penstock directly from the distribution reservoir. The draft tubes, of steel plate and concrete, open into a 4180 ft. long discharge tunnel with a cross-section of 538 sq. ft. In the tunnel are two surge chambers with air to damp out hydraulic shocks, caused by sudden changes in the load. The water being carried through rock from intake to tailwater, freezing is completely avoided even in extreme arctic weather and, as a matter of fact, the operation is considerably easier at Porjus, well north of the arctic circle, than it is a Trolhättan and Älvkarleby, in Sweden proper, where ice troubles must be guarded against. A further development is projected, calling for six additional generating units with their tunnel systems.

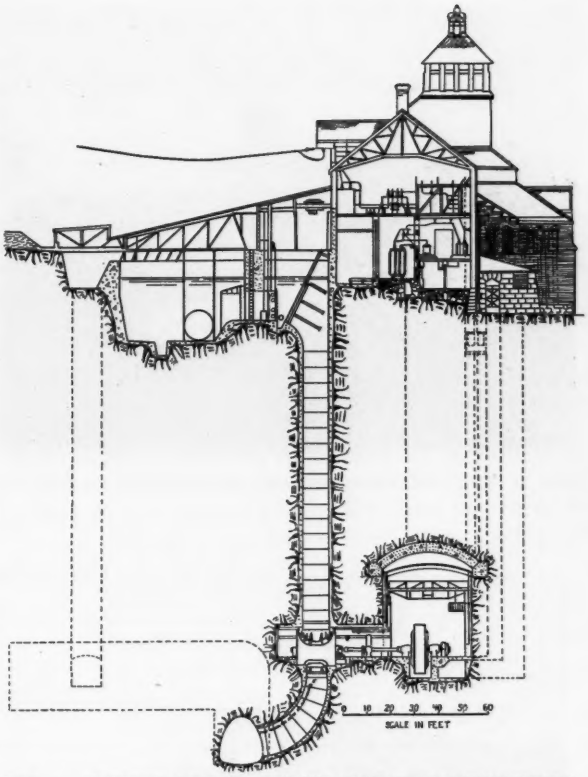


FIG. 2. SECTION OF THE PORJUS POWER STATION SHOWING THE GENERATOR ROOM 168 FT. BELOW THE SURFACE AND THE SUBSTATION ABOVE

The generator room of the present plant, 168 ft. below ground level, is excavated in solid rock. This room is approximately 300 ft. long by 33 ft. wide and contains the following equipment:

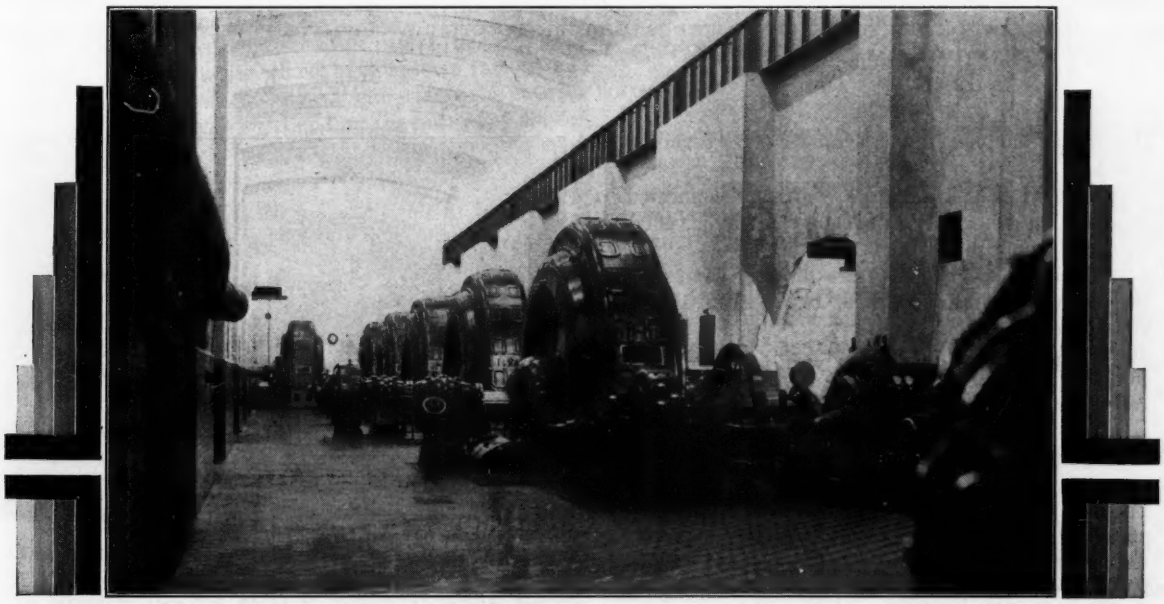


FIG. 3. A VIEW OF THE GENERATOR ROOM 168 FT. BELOW GROUND IN SOLID ROCK

FIG. 4. THE SWITCHHOUSE AND SUBSTATION AT PORJUS

elevators. In a transformer station in the substation building, all single-phase energy is transformed to 80,000 v. and part of the three-phase output is stepped up to 70,000 v. The 25-cycle transformers are built single-phase, of an oil-submerged shell type, with water-cooling. Besides transformer station, buses, switch galleries and control-room the substation building contains pump-room and tanks for oil and water, repair shops, store-rooms, offices and like quarters.

The Porjus power development is known definitely to be the farthest Polarward electrical generating plant in the world. According to the records of the National Electric Light Association, the power station at Nome, Alaska, is the second, but that is slightly south of the arctic circle, as is the third, at Trordjheim, Norway, while the southernmost operations in the Southern Hemisphere are in Tasmania and New Zealand, well within the Temperate Zone.

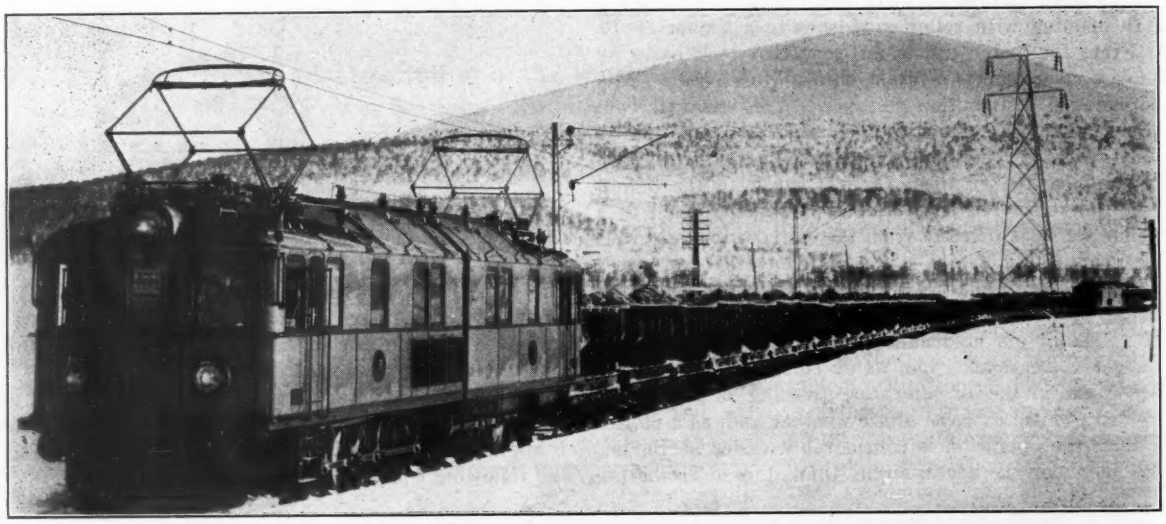


FIG. 5. HOW PART OF THE POWER GENERATED IS USED. AN ELECTRIC LOCOMOTIVE PULLING A TRAIN OF ORE NEAR KIRUNA, LAPLAND, IN WINTER

7 Horizontal, double runner Francis type turbines of which

3 developing 13,500 hp. each, are directly connected to single-phase generators rated at 10,000 kv-a., 4000 v., 15 cycles and running at 225 r.p.m.

2 developing 15,000 hp. each are directly connected to three-phase generators rated at 13,500 kv-a., 11,000 v., 25 cycles, 250 r.p.m.

1 developing 13,000 hp. at 225 or 250 r.p.m. is directly connected to one single-phase and one three-phase generator rated as above (this being a spare unit) and

1 developing 15,000 hp. at 250 r.p.m. directly connected to a three-phase generator rated at 13,500 kv-a., 11,000 v., 25 cycles and intended for a future three-phase generator rated at 9000 kv-a., 6000 v., 50 cycles.

A substation is erected vertically above the generator room, on ground level, and communicates with the latter by a cable shaft, with combined passenger and freight

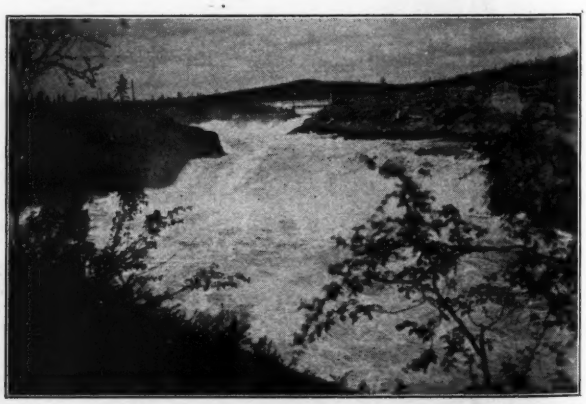


FIG. 6. A LAND OF SWIRLING, RUSHING WATER FALLS

In summer, when King Frost releases his grip this arctic rapids at Borjus provides light, heat and power for mining and a railway community of 14,000, but even in winter when the surface waters are frozen, the sub-surface currents provide ample power to operate the turbines.

Electricity---What It Is and How It Acts*

PART XLVII. REFLECTION AND REFRACTION OF X-RAYS BY MEANS OF THE ORDERED ARRANGEMENT OF ATOMS IN CRYSTALS. BY A. W. KRAMER

LAUE'S HYPOTHESIS and its substantiation by direct experiment proved to be of immense value in the fundamental investigations of the structure of matter. In this series of articles we have spoken freely of atoms and electrons, not only as separate entities but also collectively as they enter into the structure of matter. In the very early chapters of this series[1] it was shown that the various properties of the different elements were due to a difference in the number of electrons normal to each atom and that if the elements were

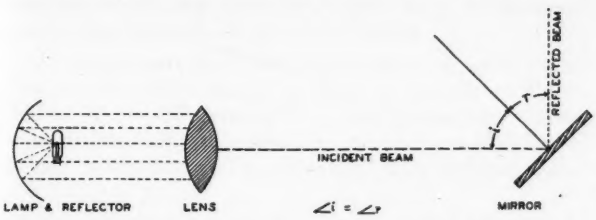


FIG. 1. REFLECTION OF LIGHT BY MEANS OF A MIRROR
The incident beam striking the surface of the mirror at an angle of 45 deg. is reflected in a direction at right angles to the incident beam.

arranged successively in the order of their increasing atomic weights, the number of electrons in successive elements varies by one.

Now, this is a very simple and logical theory but what is the evidence to demonstrate its truth? It is true that the constant increase in the atomic weights from element to element provides a clue, but at best this is inconclusive, for the increase is not orderly. How then can we assume that such a definite order exists?

This is where Moseley's work enters. Moseley was a young English physicist who was killed in the world war but despite his short scientific career, he performed a series of experiments which have become famous and which have been of the utmost importance in clearing some of the mysteries surrounding the nature of matter. Moseley's work was based partly upon Laue's. Laue's discovery as described in the previous chapter made possible the accurate measurement of the wave lengths of x-rays by the application of crystals as natural diffraction gratings, and at the same time provided a means whereby the actual spacing and arrangement of the atoms in a crystal could be determined. Moseley, by slowly rotating a crystal, first succeeded in resolving the characteristic radiation into a spectrum in a manner similar to the analysis of visible light by means of the gratings ordinarily used in optics.[2]

PRINCIPLES INVOLVED IN REFLECTION OF LIGHT AND X-RAYS

Before we discuss the work of Moseley, however, it will be of advantage to consider in greater detail the principles involved in x-ray diffraction by the Laue method. In the first place, why is it necessary to use a crystal? To explain this, first let us consider the case of reflection with ordinary light.

When a beam of light is made to fall on a smooth or polished surface such as a mirror, it will be reflected at an angle which is equal to the angle at which the light strikes the surface. That is, the angle of reflection is equal to the angle of incidence. In Fig. 1 the beam of light strikes a mirror at an angle of 45 deg., hence, the reflected beam leaving the mirror at 45 deg. is at right angles to the incident beam. This phenomenon of reflection holds true regardless of what color (wave length or frequency) light is used.

If, however, instead of light, we attempt to do the same thing with a beam of x-rays, which, as has been shown, is really nothing more than light of exceedingly short wave length, we find that it cannot be done because the beam of x-rays will be found to be scattered. There is no definite angle of reflection; the x-rays instead are scattered in all directions as shown in Fig. 2,

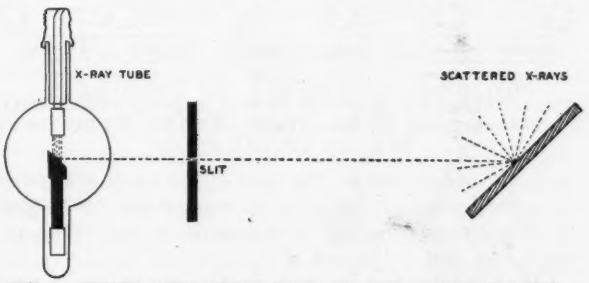


FIG. 2. WHEN THE SAME EXPERIMENT SHOWN IN FIG. 1 IS ATTEMPTED WITH X-RAYS INSTEAD OF LIGHT THE METHOD FAILS
The beam of x-rays instead of being reflected at a definite angle as in the case of light is scattered in all directions due to the fact that no ordinary mirror can present a smooth surface to x-rays.

This is due to the fact that no ordinary surface can be "smooth" to x-rays. Reflection is possible only if the surface irregularities of the reflecting body are small in comparison to the "wave length" of the incident radiation. Now, in the case of ordinary light, the wave length is approximately one fifty thousandth of an inch while the diameters of the molecules in an ordinary solid are only a fraction of a millionth of an inch hence, the surface of a solid presents a comparatively smooth surface to a beam of light causing most of it to be reflected. In the case of x-rays, however, the wave length is only about half the diameter of an ordinary molecule. No surface, therefore, can be smooth to x-rays and no reflection can take place.

Why, then, are x-rays reflected by a crystal? Are not the atoms and molecules in a crystal of the same size and is not the spacing between them of the same order of magnitude as in an ordinary solid? They are, but as has already been pointed out, in a crystal, the

*All rights reserved.
[1]Chapter III.
[2]See Chapters XXVII and XXVIII, September 1, and September 15, 1929 issues.

spacing is regular, not haphazard as in a non-crystalline solid and this makes a difference.

To explain just how such a regular spacing of atoms or molecules can cause reflection, let us refer to an analogy given by Sir. Wm. Bragg.[3] Let us imagine ourselves to be walking along the sea shore, watching the incoming waves. We come in the course of our walk to a place where the strength of the waves is less and when we look for the reason we observe a reef out to sea which is sheltering the beach. We have in this, a parallel to an optical shadow, as when a cloud passes between us and the sun. The optical shadow enables us to detect the presence of the cloud—the silence on shore makes us suspect the presence of the reef.

Now the dimensions of the reef are much greater than the length of the ocean wave, hence the ocean wave is reflected by the reef and its energy fails to reach the shore. If, however, in place of the reef there was substituted a pole planted in the bottom of the sea and projecting above the surface, the effect would be too small to observe. This of course is obvious. Even if we had a large number of poles so that the effect mounted up and was as great as that of the reef, the resulting shadows would tell us nothing about each individual

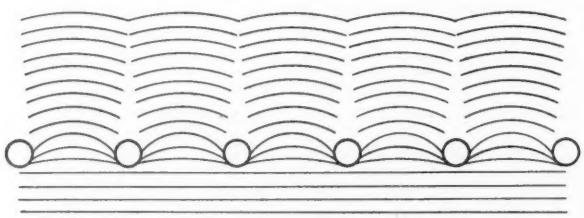


FIG. 3. DIAGRAM SHOWING HOW A ROW OF POLES WILL CAUSE SHADOWS OF SHORT WAVES TO BE PRODUCED IN THE LEE OF THE POLES

pole. The diameter of the pole is too small compared with the length of the wave to impress any permanent character upon it. The wave sweeps by and closes up again and that is the end of it.

If, however, the sea was smooth except for a tiny ripple caused by a breath of wind, each pole could cast a shadow which would persist for at least a short distance to the lee of the pole. This is shown in Fig. 3. The width of the ripples is less than the diameter of the pole; as a consequence, there is a shadow to each pole.

This last condition is analogous to the reflection or refraction of x-rays by molecules. As long as ocean waves of considerable length impinged on the row of poles we received no impression of their existence. When, however, tiny ripples were employed, the existence of the poles could be detected by the shadows cast.

The Value of X-rays in Our Investigations of Matter

In the same manner, light waves sweeping over molecules much smaller than themselves receive no impression which can be carried to the eye and hence to the brain to inform us of the existence of these molecules. Thus with ordinary light we cannot hope ever to "see" molecules, much less atoms. This limitation, it is evident, is due not to any shortcomings of our eyes, for if it were we could overcome the difficulty by the use of instruments such as the microscope. The microscope, it is true, increases our power of perceiving small things; with its help we may detect objects thousands of times smaller than could be seen with the naked eye, but it fails when we try to see things which are of the same size as the wave length of the light by which we see. No possible increase in skill, or in the power of our microscopes or even in the development of our eyes can be of any help in this matter. The limitation is one which is concerned with the wave length of the light and for this reason the x-ray has removed much of the difficulty. X-rays are some 10,000 times finer than ordinary light and provided suitable substitutes can be found for the eye (eyes, so to speak, which can see by means of x-rays) we can go some 10,000 times deeper into the mysteries of structure. This brings us comfortably into the region of atoms and molecules which have dimensions in various directions of the order of a

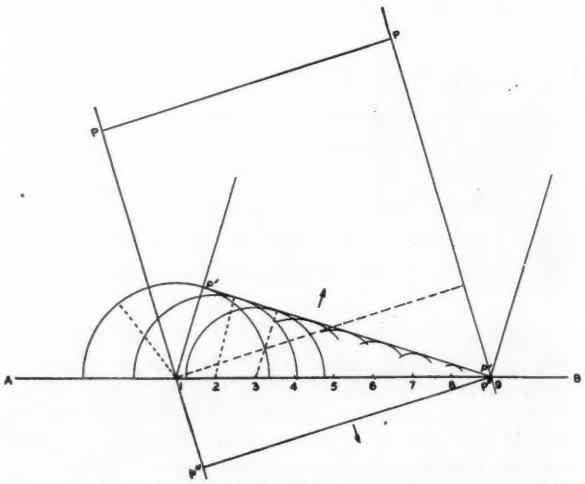


FIG. 4. PRODUCTION OF REFLECTION BY THE ORDERED ARRANGEMENT OF ATOMS IN CRYSTALS

hundred millionth of an inch. X-rays, in other words, have increased our keenness of vision 10,000 times.

Our analogy with poles in the ocean, gives us an indication as to what happens in the case of x-rays striking a row of molecules but it doesn't tell the entire story. We have said that x-rays are not reflected by ordinary matter. Yet, from the pole analogy, we might assume that they can be reflected for certainly the molecules in an ordinary solid can be compared to the poles in the ocean, in spite of the fact that their spacing may be irregular. What has the regularity of spacing to do with it?

Just this. Although each molecule can now affect the x-ray, just as a single pole affects the ripple, the effect of any single molecule is too minute to be of consequence. And in an ordinary solid, despite the fact that there are countless billions of molecules, they are disposed in such a haphazard manner than only by change will the effect of two or more molecules reinforce each other. More than likely there will be as many neutralizations, so to speak, as there will be reinforcements; furthermore, the effects will take place in many different directions, resulting in the scattering which we already know takes place.

Now we can explain what the crystal does. It so

[3] X-rays and Crystal Structure. By Sir William and W. L. Bragg.

coördinates the effects of the individual molecules as to make the combined effect sensible. Bragg makes use of another interesting analogy in explaining this. If a single soldier in going through the manual of arms made a movement with his rifle and bayonet it might happen that the flash in the sunlight caused by the motion was unobserved a mile away because of its feeble intensity. Similarly, if a row of soldiers, were practicing, each going through the manual of arms without paying any attention to what his companions were doing, the many flashes in the sunlight caused by the movements of their rifles might not be observed a mile away for the simple reason that these flashes were occurring at different times and perhaps, in slightly different directions. If, however, this same row of soldiers were drilling in unison, receiving orders from the company commander and executing the orders simultaneously, the combined effect of all their rifles flashing in the sun at the same time and in the same direction might easily be observed a mile away because of its high intensity.

In Fig. 4 there is represented a row of atoms or molecules or even poles, as you prefer. A wave front P—P strikes this row of elements at an angle as shown. Since it is inclined at an angle, this wave front will meet element 1 first and will be reflected. This reflected wave

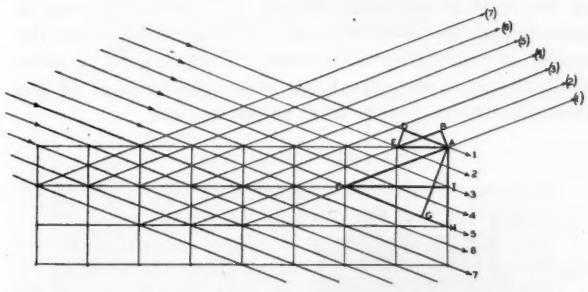


FIG. 5. SECTION OF PORTION OF A CRYSTAL SHOWING EFFECT OF INNER LAYERS OF ATOMS IN PRODUCING REFLECTION

will spread out as a circle 1′. An instant after this reflected wave has been formed, the incident wave P—P strikes element 2 setting up another reflected way 2′ which is just a trifle behind 1′ in time and displaced from it slightly in space.

This action, of course, is repeated for every element 3, 4, 5, ... 8 and 9 in the row with the result that at a subsequent time when the wave front P—P has reached P″—P″ there will be disposed in front of the row of atoms or poles a series of small wave fronts 1′, 2′, 3′ ..... 8′, and 9′. A line P′—P′ drawn through these waves fronts forms the front of the reflected wave. Thus, it can be seen that the combined effect of a series of small waves set up by a row of separate elements, poles, atoms or molecules, is such as to give rise to the phenomena of reflection and diffraction.

In this example we have considered only a single row of atoms. X-rays, however, are able to penetrate matter and because of this the layers of atoms in the interior of the crystal are brought into play as well as the top.

Suppose we represent the atoms in a crystal by the dots in Fig. 5. Now assume a course of X-rays at such a distance so that the wave fronts may be considered to be planes. The arrows 1, 2, 3 ..... then represent normals to these waves fronts. Then the arrows (1), (2), (3) will represent the corresponding normals for the reflected or diffracted beam. Each layer of atoms contributes its share to the establishment of the diffracted wave in the manner shown.

Experimentally, it is found that the grazing angle of incidence and of emergence are equal, i.e., that DAE = BEA. Let AG be drawn perpendicular to FH. Then AFI = HFI and FA = FH = FG + AH sin GAH = FG + AH sin DAE. Thus the path of the beam 5 to the point G is equal in length to the path of beam 1 to the point A. The difference in path length between the beam 1 at A and the beam 5 diffracted from F to A is AH sin DAE. Since AH is twice the interplanar distance d of the crystal and DAE is the grazing angle Θ, we know the waves diffracted along (1) from incident beams 1 and 5 will meet in phase if

$$n\,L = 2\,d \sin \Theta$$

in which n is any whole number; L is the wave length of the X-ray used.

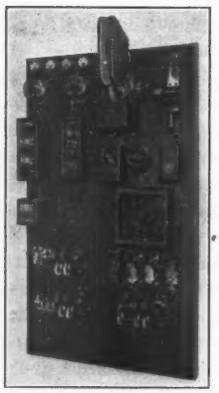
It is possible, therefore, to have a whole wave front of diffracted X-rays emerging from a crystal at an angle equal to the angle of incidence, provided this angle is related to the wave length of the X-rays and the interplanar distance of the crystal in the manner shown by the equation shown above.

W. P. Yant Appointed Supervising Engineer of Pittsburgh Station U. S. Bureau of Mines

APPOINTMENT OF W. P. YANT, of East Sparta, Ohio, as supervising engineer of the Pittsburgh Experiment Station of the United States Bureau of Mines, Department of Commerce, effective Jan. 5, is announced by Scott Turner, Director of the Bureau. Mr. Yant succeeds G. St. J. Perrott, who has accepted a position on the research staff of the A. O. Smith Corp., Milwaukee, Wis.

Mr. Yant graduated from the College of Wooster, Wooster, Ohio, in 1918. Immediately following graduation, he joined the staff of the Chemical Warfare Service at American University, Washington, D. C., and was assigned to work on the development of gas mask absorbents for war gases. Following the war, he was instructor in chemistry at the College of Wooster. He joined the gas laboratory staff of the United States Bureau of Mines in 1920 and was assigned to problems pertaining to mine, industrial and fuel gases. In 1923 he was appointed chemist-in-charge of the Bureau's gas laboratory and in 1925 he became supervising chemist of the health laboratory section.

Mr. Yant is the author of many publications of the Bureau of Mines and of articles which have appeared in technical journals. He has been granted two patents, one for a simple method for quantitatively determining the carbon monoxide in the blood of supposed victims of poisoning and which is widely used in hospitals and by health officials; the other for the use of helium and oxygen mixtures rather than normal air in diving and caisson operations at high pressure.



AUTOMATIC *Switching Equipment for Synchronous* MOTOR-GENERATORS

By D. C. Hoffman
Switchgear Eng. Dept.
General Electric Co.

AN IMPROVED design of automatic switching equipment has been made available recently for use with motor-generator sets rated 150 to 300 kw., 275 v. d.c., 2300/4000 v. a.c., three phase, 60 cycle. The principal features are the new starting and running contactor and the compact arrangement of the high-tension switching equipment, shown in Fig. 1. The starting and running contactor, in itself very compact, is mounted in an angle-iron framework together with the oil circuit breaker E, current transformers D and potential transformers C. The starting auto-transformer A is mounted on the top of the same frame. All high tension wiring (such as the connections at B) between these various devices is done in the factory.

As shown in the photograph at the head of this article, the d.c. line contactor, emergency air circuit breaker and control relays and contactors are mounted on two standard ebony asbestos panels. One of these panels is 20 by 76 in. and the other is 24 by 76 in., making a total control board width of 44 in.

A rear view of this control board in Fig. 3 shows the main circuit copper connections and neat arrangement of the control wiring. It is only necessary for the user to connect the feeder cable and the generator cable to the proper lugs, as all of the other main circuit connections are made in the factory.

As shown in Fig. 2, the high-tension framework can be completely covered with readily removable steel cover plates. These cover plates are furnished at the option of the user.

Summary of Operation

An elementary diagram of connections is reproduced in Fig. 4 as an aid to the reader in following the sequence of operation. The main power connections, both a.c. and d.c., are shown on the extreme left end of the diagram. The oil circuit breaker 52 is manually operated and is normally kept closed. The starting contactor 6 and the running contactor 42 are under the control of the automatic switching devices. The machine is started on reduced voltage obtained from the auto-transformer when the starting contactor 6 is closed. After the machine comes up to synchronous speed, the starting contactor 6 is opened and the running contactor 42 is closed to connect the motor directly to the a.c. incoming line. The field of the motor is connected to the armature of the generator by means of the field contactor 41. The generator is connected to the load by the d.c. contactor 72 and the emergency air circuit breaker 71, which is manually operated and normally kept closed.

Complete connections of the motor-generator set and all of the switching and control devices are shown in the elementary diagram in Fig. 4. Reading from left to right across the diagram, the circuits are arranged in approximately the sequence in which the devices operate. It will be noted that the coils and contacts of the devices are not shown together, but are located in the circuits in which they are used. A set of symbol pictures is included at the bottom center of Fig. 4 to assist the reader in visualizing the devices. These symbol pictures show the arrangement of the coils and contacts of the most important devices used in the control.

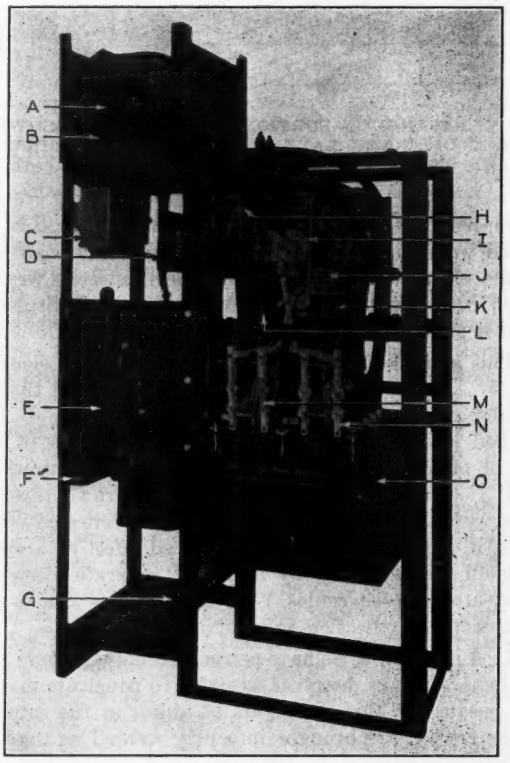


FIG. 1. AUTOMATIC SWITCHING EQUIPMENT, STARTING AND RUNNING UNIT FOR 275-V., 220-KW. SYNCHRONOUS MOTOR GENERATOR

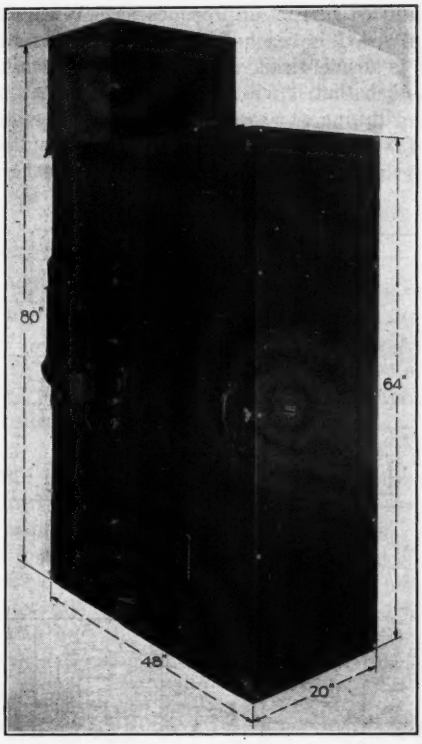


FIG. 2. HIGH TENSION FRAMEWORK COVERED WITH STEEL PLATES

Details of Operation

Control Power

Power for operating the control relays and switching devices is obtained from a control power transformer 11, the primary of which is connected to the a.c. incoming line ahead of the disconnecting switches. The control voltage is 220, but the transformer is provided with a mid-tap in order to obtain 110 v. for the potential coil of the a.c. undervoltage relay 27. A potential transformer connected to the a.c. incoming line below the disconnecting switches furnishes 110 v. for the other coil of relay 27. The control power transformer 11 and the potential transformer are on different phases of the line, as 27 is a three-phase relay.

The Starting Indication Is Given

The motor-generator set is ready to start when the manually operated disconnecting switches, oil circuit breaker 52, control power switch 8 and d.c. emergency circuit breaker 71 are closed. This is the normal shut-down condition of the substation, and the starting and stopping of the set are then under the control of the master element 1 or 1A. If the double throw switch 1 is in the "remote control" position, the machine is started by closing the remote switch 1A. If it is desired to start the machine at the substation, the switch 1 is thrown to the "local" position and the set starts immediately.

When either switch 1 or 1A is closed in the position to start the set, relay 27 will close its contact in the coil circuit of master contactor 4. The a.c. undervoltage relay 27 prevents the set from starting if normal three-phase voltage of correct phase rotation is not present. The contacts of all the protective devices of the set are also in the coil circuit of 4, which means that the set cannot be started unless the protective devices indicate that conditions are proper to do so. These protective devices are three bearing thermal relays 38, the over-speed switch 12, and the a.c. machine thermal relay 49. Normally-open auxiliary switches of the oil circuit breaker 52 and the d.c. emergency circuit breaker 71 are also in this circuit.

The Starting Contactor 6 Closes

When the master contactor 4 closes, its contact 2 energizes the undervoltage device (UVD) of the starting contactor 6, shown at J in Fig. 1. The closing coil L of 6 is energized at the same time and the starting contactor closes. The time delay opening interlock 1, shown at H in Fig. 1, deënergizes the closing coil of 6 after the contactor is mechanically latched and held in the closed position by latch M. The auto-transformer is now connected to the a.c. incoming line, which permits the starts on reduced voltage obtained from the auto-transformer.

It should be noted that the normally-closed interlock 4 of the running contactor 42 is in series with the closing coil of the starting contactor 6 to prevent 6 from closing at any time when 42 is closed. If a.c. voltage should fail during the starting period, the undervoltage device (J in Fig. 1) is deënergized, drops down and trips the starting contactor 6, disconnecting the motor from the line. The contact 2 of master contactor 4 also energizes the starting protective relay 48 at the same time that the starting contactor 6 is energized and 48 begins to time for incomplete start.

FIG. 3. REAR VIEW OF CONTROL BOARD

The field circuit of the generator includes a hand operated rheostat and a field killing resistor. The field killing resistor is shunted by the contact 3 of master contactor 4 and therefore has no effect while the machine is in operation. When the set is shut down, however, contact 3 of contactor 4 opens and inserts the field killing resistor, quickly reducing the generator voltage, of the induced current approaches zero. When exact synchronous speed is reached the induced current is zero and 13 is deënergized. The magnetic circuit of this relay is such that it will hold its contact open until the motor is running at exactly synchronous speed; that is, relay 13 will not drop out until the motor has passed through the last half slip cycle. This feature is ob-

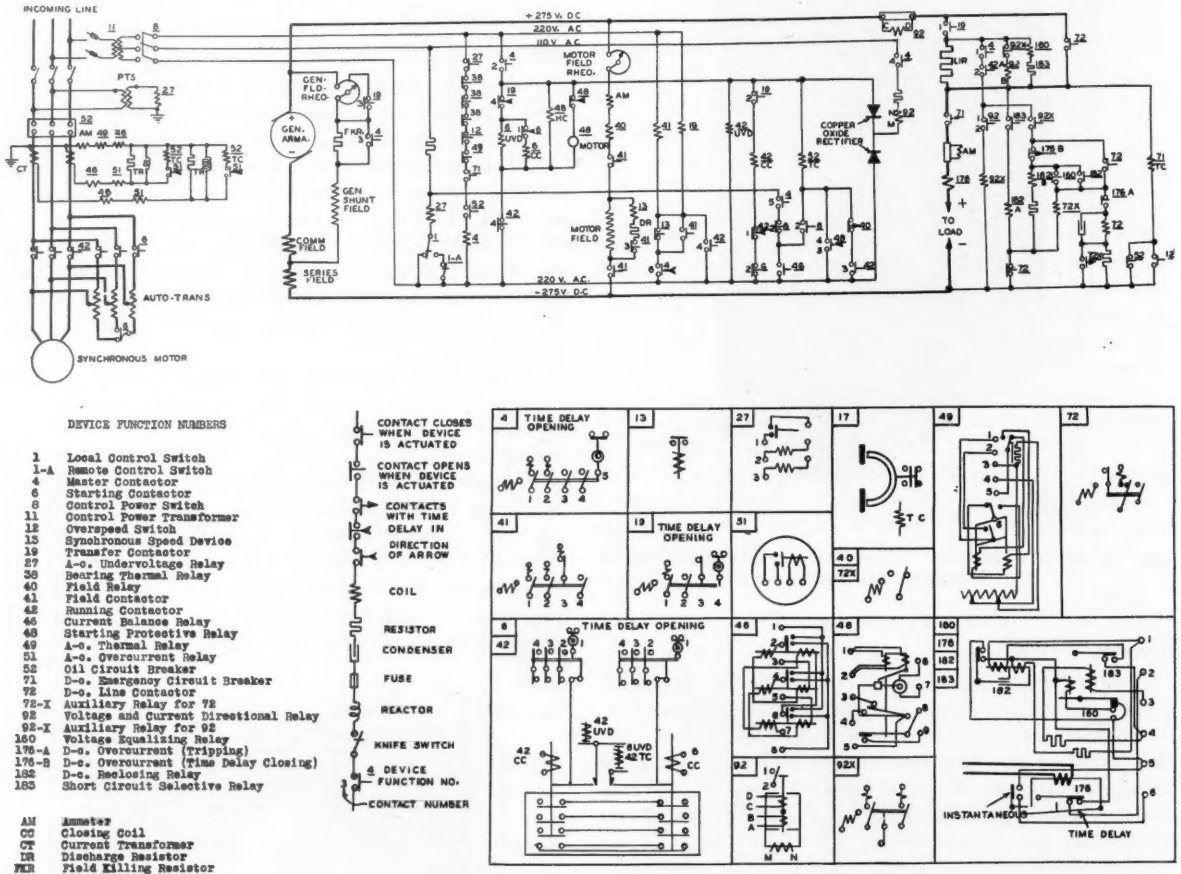


FIG. 4. DIAGRAM OF CONNECTIONS OF AUTOMATIC SWITCHING EQUIPMENT

and allowing the set to be started again within a very short time, if necessary. In order to insure that the generator will never fail to build up voltage, a part of the field rheostat is shunted during the starting period by the normally-closed contact 3 of the transition contactor 19. A sufficient amount of resistance is shunted to permit the generator voltage to build up to about normal value in the time required for the motor to reach synchronous speed.

The Motor Reaches Synchronous Speed in the Starting Cycle

The motor field contactor 41 is open during the starting period, but the motor field is connected to the coil of the synchronous speed relay 13 through the normally closed contact 3 of field contactor 41 and the field discharge resistor. When the motor is below synchronous speed, an alternating current is induced in the field winding and relay 13 is energized by this current. As the motor approaches synchronous speed, the frequency

tained by pole shading in the magnetic circuit, and no other time delay attachment, such as a bellows, is used.

Motor Field Excitation Is Applied

The generator voltage has built up to about the normal value when the motor reaches synchronous speed. As soon as relay 13 indicates that synchronous speed has been reached, the coil circuits of the field contactor 41 and transition contactor 19 are completed by the normally closed contact of 13. The two contactors, 41 and 19, are connected in parallel and are therefore close together. When 41 closes, the field of the motor is connected to the generator circuit through the field relay 40, the field ammeter and the motor field rheostat. The coil of 13 is disconnected from the circuit by the opening of contact 3 of 41. The field current causes the motor to pull into exact synchronism with the line. The transition contactor 19, which picked up at the same time as 41, transfers the motor from the starting to the running connection after a short time delay during which the motor pulls into step and becomes stable. This

transfer takes place when the normally closed time delay opening contact 4 of 19 opens the circuit of the undervoltage device on the starting contactor 6, causing it to trip the latch and open 6. The interlock 2 of 6 then completes the closing coil circuit of the running contactor 42, which closes in the same manner as the starting contactor 6. The undervoltage device (I Fig. 1) must be energized, or 42 will not remain closed. The motor is now connected directly to the line.

The Generator Is Connected to the Load

After the running contactor closes, the generator is ready to be connected to the feeder load by the closing of the line contactor 72. The voltage and current directional relay 92 will not allow the line contactor 72 to close unless the polarity of the generator is correct and the generator voltage is slightly higher than feeder voltage.

The field coil M-N of 92 is energized by direct current obtained from the a.c. control power bus through a full-wave copper oxide rectifier. It therefore has a positive fixed polarity against which the polarity of the generator is checked before allowing it to be connected to the feeder. The coil A-B of 92 is connected between the generator and the feeder and therefore determines whether the generator voltage is higher or lower than the feeder voltage.

As soon as the generator voltage is higher than the feeder voltage, 92 closes its contact 1—2 and energizes the auxiliary contactor 92X. If there is no overload on the feeder, the line contactor 72 closes and connects the generator to the feeder. If overload exists on the feeder, the contactor 72 will be prevented from closing by the d.c. recloser until the load is reduced to a safe value for the generator.

The starting sequence is now completed and the generator is supplying the feeder with power. Although there are quite a number of steps in the sequence from the time the starting indication is first given until the time the generator is connected to the load, the entire operation actually takes place in about 30 sec.

Protective Features

This equipment is especially designed for mining service and is intended for operation on stub feed as well as on multiple feed. It has a number of protective features which guard the motor-generator set against abnormal conditions. If the trouble is of a temporary nature, the set is shut down and allowed to restart as soon as the trouble has cleared itself. If the trouble is such that an inspection must first be made, the set is locked out and prevented from restarting. Among the conditions against which the set is protected are, abnormal a.c. voltage, single-phase and unbalanced line currents, a.c. overcurrent, overheated windings, loss of motor field excitation, d.c. reverse current, d.c. undervoltage, d.c. overcurrent and short circuit, overspeed, and overheated bearings. It is also provided with restart and incomplete start protection.

Operating Experience Crystallizes Boiler Practice

Trend in Boiler, Superheater and Economizer Design as Determined by the Prime Movers Committee of the N.E.L.A.

METHODS OF DETERMINING the steaming capacity of a boiler in the past have depended upon the assumption that the rate of heat liberation in the furnace, or the date of heat absorption by the boiler tubes, was practically a constant for most installations. In general, this was true as long as hand firing existed and boiler pressures remained moderate; but, with present stoker and pulverized fuel firing methods and with the various kinds of heat absorbing surface, this method of rating boilers has become obsolete. With improvement in firing methods, it has been possible to force boilers to 1500 per cent of nominal rating given by the old method of figuring boiler capacity.

Likewise, with the introduction of water walls and water screens it was found that such surfaces, as well as the lower banks of tubes which are exposed to the direct effect of radiant heat, absorb more heat in proportion than do the more remote sections of the boilers. In order to calculate correctly the actual steam generated on the basis of total heating surface, it would be necessary to segregate each section of the boiler and calculate the steam generated therein by applying the appropriate rate of heat transfer for the section. The combined result would give the total generating capacity of the boiler. As this method is very tedious and practically impossible to calculate accurately, a simpler method of rating boilers is desirable.

A much better way of rating boilers is on a heat liberation basis expressed in B.t.u. The steam-generating capacity should be stated in one of the following ways: Pounds of steam evaporated per hour; heat liberated in the furnace together with an overall efficiency and the operating or limiting steam pressures, temperatures and feedwater temperatures; A.S.M.E. evaporation units (1000 B.t.u., symbol kB) together with the operating or limiting steam pressures and temperatures.

Boiler Outage Importance Overemphasized

Tendency of modern boiler practice is toward one boiler unit per generating unit with a spare to take care of the plant during outages of boiler units. The question of boiler outage always arises when a plant is being designed for a certain capacity factor, where the reliability of availability of the boiler units must be accurately foreseen. Factors which, in the past, have been the basis for estimating boiler outages are: Outage increases directly with the severity of use; method of burning fuel has a definite bearing on reliability; different fuels have a bearing on reliability. More recent data indicate that these factors are not so important as previously considered.

It appears that details of design, construction and operating skill are far more important in obtaining a high availability factor than are such things as rate of

output per unit of surface, type of fuel, method of firing and many of the other factors which have been widely discussed in this connection. Indications are that boiler outages are not proportional to severity of use, as more boiler outages are recorded in data collected for low rates of heat transfer than for those working at higher rates.

Pressure Trends Here and in Europe Differ

Steam pressures in use in the United States have increased to 1400 lb. while in Europe higher pressures have been used but in smaller units. The trend of high-pressure boiler design in the United States has been similar to that for the low-pressure unit, while in Europe radical changes have been made in which smaller drums, and in some cases no drums at all, have been used.

Costs of boiler drums forged from solid ingots has been a considerable item in the cost of high-pressure stations; however, to offset this higher cost of boiler drums and high-pressure heating surface, the surface of the economizers, air heaters and water walls has been increased and the surface of the boiler decreased. Due to these changes in design, as well as lower turbine water rates and bleeding for feedwater heating, which permit the use of smaller condensers, smaller buildings, less fuel and ash handling equipment, the cost of high-pressure plants has been reduced to values comparable with those of low-pressure units.

Water Walls

Use of water walls has increased, thus reducing maintenance on refractory type walls and increasing boiler reliability as well as increasing the heating surface of the boiler unit. In some cases where the furnace is entirely enclosed with water walls, as much as 40 to 65 per cent of the heat absorbed by the boiler is being absorbed by the water walls.

Caustic Embrittlement

The question of prevention of caustic embrittlement in boilers has been the subject of much argument. It is generally agreed, however, that embrittlement can be prevented by maintaining the sulphate or phosphate carbonate ratio of the feedwater, the ratio rising with the pressure. The use of welded boiler drums has been advocated as means of preventing embrittlement. Although the use of welding in construction of boiler parts exposed to pressure has not been approved, it may be used in a number of cases such as attachment of brackets, supports and other mechanical fastenings to boiler shells.

Superheaters

Steam temperatures of 750 deg. F. are in use in this country, while in Europe temperatures in the neighborhood of 900 deg. F. have been used. A notable experimental installation of a high temperature unit in this country is that of the Detroit Edison Co. The unit is of 10,000 kw. capacity and designed to use steam at 1000 deg. F.

Steam temperatures at present are limited to 750 deg. F. by the lack of a suitable reasonably priced alloy for superheater coils, which will stand higher temperatures. Research is progressing, however, and it is hoped that such an alloy may be found which will open up the field of higher steam temperatures. Recent improvements in design of superheaters indicate that superheaters will give satisfactory service and manufacturers will guarantee them for temperatures up to 850 deg. F. Such superheaters are similar in design to the single-pass superheaters, a number of which have been installed during the last year. Superheater design has been improved to reduce pressure drop and to distribute the steam more equally throughout the tubes.

Corrosion by Superheated Steam

Study of the corrosion of superheater tubes by steam indicates the following: With oxygen free steam, corrosion due to the rate of reaction between steam and steel superheater tubes is negligible for steam temperatures up to 800 deg. F. and tube temperatures up to 950 deg. F.; the use of superheaters made of Enduro KA-2 tubes with temperatures on the fire side up to 1200 deg. F. is not limited by the reaction between iron and steam; hydrogen gas evolution (and corrosion in general) is accelerated by oxygen entering the system with the feedwater and the oxygen content of this water should be reduced to the lowest practical quantity; within limits the alkalinity of the boiler water will have no noticeable effect on the rate of reaction between iron and steam. A definitely alkaline boiler water and boiler feedwater is prferred to prevent acid corrosion and limit corrosion due to other conditions. However, alkaline water does not stop corrosion due to oxygen.

The practice of placing the superheaters closer to the fire, instead of protecting them by placing the coils above the lower boiler tubes, is gaining favor. In many cases, the superheater coils are exposed to the fire, while the superheater headers are constructed back of the furnace wall.

Reheaters

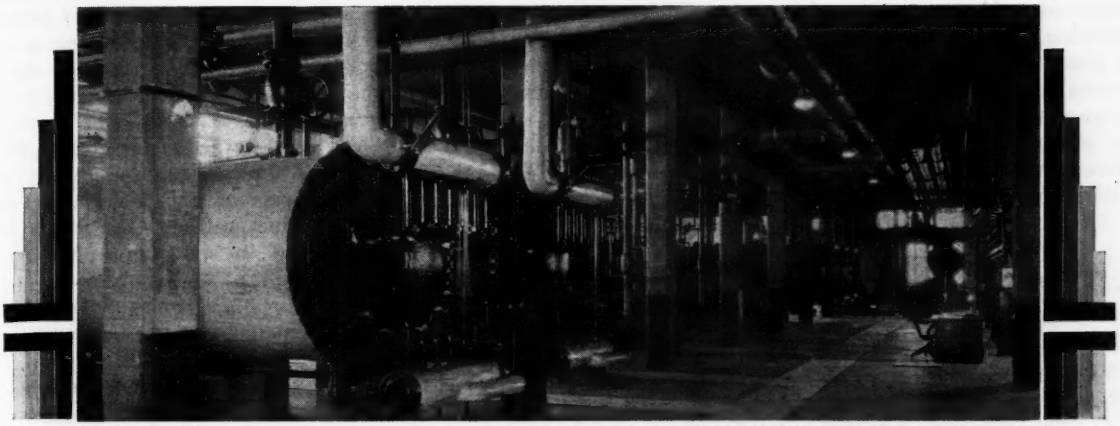
Due to the increasing practice of reheating the steam between the high-pressure and low-pressure stages of a turbine, the use of reheater units installed in connection with standard boilers is becoming common practice.

Economizers

In order to reduce the expensive boiler surface necessary in case of high-pressure steam installations, the use of steaming economizers is gaining favor. It has been demonstrated by experience that internal corrosion need not be a factor in maintenance where condensing and deaerating equipment is used and the feedwater is largely condensate; however, external corrosion has been experienced due to acid from the flue gases.

When repairing old foundations, grease and oil should be thoroughly removed before the new concrete is added. Potash dissolved in warm water is best for this but if potash is not easily procured a can of concentrated lye dissolved in a pail of water will answer the purpose. After thoroughly scrubbing with this solution, the concrete should be thoroughly washed with water. This solution must be handled carefully as it will burn both cloth and clothing.

When testing rotary pumps the net output or discharge can be determined only by actual test.



Progress in Refrigeration During 1930

By W. R. Woolrich
Professor, Mechanical Engineering
University of Tennessee

FOR THE YEAR 1930, no other industry has experienced as great an increase in popular appreciation or as great a development and interest in the many applications of its fundamental principles as refrigeration.

Seemingly, the industry as a whole has awakened to the fullness of its opportunities. Even in a year when most major industries wavered and were depressed, refrigeration developments on every side indicated greater activity and an optimistic tone.

Compressor Developments

Compressor developments continued their trend to higher speeds. The general change made within the past decade to short-stroke high-speed compressors at first entailed no great increase in piston speed. An 8 by 8-in. stroke twin compressor at 250 r.p.m. would replace a 60-r.p.m. machine with a bore of 15 in. and a 30-in. stroke; thus, the increase was in revolutions with practically no increase in speed of piston travel. This change to higher speeds, once initiated, has continued. Lighter valve parts have been introduced, more foolproof lubrication systems developed and larger port openings designed into the machines.

Within the past year, several installations have been made with piston speeds increased to as high as 600 ft. per min. or over. American practice still dictates that the poppet or the plate valve be used with a growing preference to plate valves on account of their larger port opening and lighter parts.

In Europe, an increasing number of compressors in 1930 have been made with sleeve valves. Piston speeds from 700 to 850 ft. per min. are in operation with anticipated increases to speeds above 1000 ft. per min.

Rotary compressors, introduced specifically for compression of low-pressure refrigerants, have fulfilled expectations in their trials over the past few years and an increasing number of these units are being adapted to air conditioning service throughout the United States, but as yet the rotary compressor has not been generally accepted for high-pressure work.

The most outstanding feature of the progress in compressor manufacture in 1930 has been the almost universal acceptance of the practice of using double suction compressors in plants requiring two or more suction pressures. Since the first suggestions were offered by Mr. Vorhees nearly a quarter century ago,

Professor Woolrich, whose article appears on this page, has been a frequent contributor to the pages of Power Plant Engineering and his survey of this year's developments in Refrigeration will be welcomed by the many readers who have followed his articles. Professor Woolrich began his experience in the field as an operating power plant engineer in Southern Wisconsin in 1905. From 1907 to 1911 he attended the University of Wisconsin doing part time work with the Wisconsin Railroad rate commission and the Commonwealth Edison Co. of Chicago. After graduation, he became instructor of steam engineering and design at De Paul University in Chicago remaining there until 1912. From 1912—1913 he was manufacturing apprentice and assistant consulting engineer at the Western Electric Co. and from 1914-1916, consulting engineer and supervisor of apprentices at the International Harvester Co.

Since 1916 he has been with the University of Tennessee at Knoxville, first as associate professor and since 1924 as professor of mechanical engineering and head of the mechanical engineering department. He also carries on a consulting practice.

that multiple effect compressors would offer a solution to many of our more complex refrigeration problems, an increasing experimental interest has been displayed in the possibility of this supercharging process of compression. The trend of 1930 seems to indicate that it has passed the stage of experimental curiosity and is now admitted to be the most acceptable solution to requirements for two, three, or more suction pressures of widely varying limits.

Development in Coolers

Improvement has continued in cooler construction. Aiming towards a maximum tonnage for the investment in coils and cans, freezing tanks of trunk construction and supplied with auxiliary precooling equipment have become most commonly accepted as preferred equipment. Compressor head pressures for given cooling water conditions show a remarkable decrease by virtue of the improved parallel flow features of the header type coils and controlled flooded operating characteristics together with the higher rates of circulation of the brine through the trunk line race ways and brine tanks. It is not uncommon to find 1930 plants operating on head pressures of 120 lb. that would have been considered good if they had operated under similar conditions and on the same water temperatures at 180 lb. pressure a decade ago.

In the applications of forced ventilation air coolers, a decided increase has been experienced. While much experimental work is still incomplete on the characteristics of the various available cooling units, the initial installations have generally been conservatively rated and are giving better capacities than their listed ratings.

Reduction in corrosion in the coils of brine coolers and brine tanks by the use of inhibiting chemicals has been the natural result of the 1924 to 1928 researches of the Corrosion Committee of the American Society of Refrigerating Engineers. While this research cost probably less than $10,000, it has resulted in a saving to the nation of many times this amount in the first few years of its application.

Condenser Trends

Condenser design has experienced no revolutionary changes during the past year. In double tube condensers, the general trend, started some years ago, to reduce the height of the stands has continued.

Shell and tube condensers are receiving more and more favorable acceptance. Part of this is, no doubt, due to sales pressure, but the simplicity of construction, the accessibility for repair, the utilization of space and the very good operating characteristics have made it a favorite with many engineers.

Purging of condensers by continuous purging equipment has become more common. Furthermore, no longer is purging confined to any one point of the system, but realizing that gases of various densities may exist in the system, purging is more generally done in new installations from several strategic points.

Cold Storage

Cold storage has made several distinct advances during 1930. Terminal storage plants have been added at several important shipping centers.

In the Florida fruit area, both fruit coloring rooms and juice extraction rooms have been included as a part of the storage equipment. Production of citrus fruit juices, frozen in sharp freezers and distributed for soda fountain and baking requirements, has become a very desirable method of utilizing fruit juices that can be extracted from the excess citrus fruit supply.

In the California region, a major experiment has been launched in a state owned cold storage plant. While the Canadian Government has successfully participated in the cold storage of perishables as a means of stabilizing farm product markets, the States have been somewhat backward in assuming a commercial interest in such matters.

In the West and Midwest, egg breaking plants have increased their equipment and output; the canned egg industry is apparently enjoying a steady growth. Due to the rigid control maintained over the canned egg industry by the United States, and to the great convenience offered to bakeries and hotels for eggs of assured reputation, this industry will continue to expand until it reaches a saturation level between supply and demand.

Carbon Dioxide Refrigeration

Carbon dioxide is commanding a very prominent position in the interest of the public. The year 1930 is marked by the passing of several processes from the experimental to the commercial stage. Most prominent of these advances has been made in Solid CO_2 production. So generally has this product been accepted by the general public as the preferred packing material for ice cream shipments and deliveries, that it no longer excites comment in many American cities when the ice cream is delivered to the home packed in CO_2.

The rise in demand of dry carbon dioxide is almost unprecedented in the history of refrigeration processes. In 1925 the total amount of solid carbon dioxide used was about 300,000 lb. In 1928 this had risen to 14,000,000 lb. In 1929 there was over 300 per cent increase over 1928, the approximate deliveries equaling 44,000,000. While 1930 deliveries cannot be definitely recorded at this early date, it will probably approach a 300 per cent increase over 1929. In the plants of the heaviest producers, doubling the plant tonnage capacity has become an annual requirement.

This product has been accepted by the public with so much enthusiasm that numerous "wild cat" stock selling schemes with a mystic background have been promoted. While the industry has nipped some of these schemes, it finds it necessary to maintain strictest vigilance to prevent betrayal of public confidence in the product.

Possibilities of shipping all carbon dioxide in the solid form are being vigorously investigated. Researches indicate some definite advantages; certainly, it would reduce heavy shipping expense if this can be commercially realized.

Public interest and the great demand have brought to the front numerous supplies of carbon dioxide gas other than those formerly known. In the West, numerous wells of nearly pure carbon dioxide gas are now in operation. In Mexican territory, carbon dioxide wells furnishing sufficient pressure to give sublimation without further compression are under test and experimental shipments have been made to the United States.

Household machine refrigerator development has ex-

perienced some stabilization in the industry from the commercial standpoint. A survey by Dr. J. B. Churchill revealed that of the some fourscore of manufactured units in the United States; 30 of them are using sulphur dioxide as a refrigerant and 29 of them are using methyl chloride.

Through the efforts of several government agencies, considerable educational material giving experimental results on the comparative hazards of different refrigerants has been made available. Definite results have been secured in supplying a permanent odorant for methyl chloride and at least one large supplier is furnishing methyl chloride so treated.

A number of new refrigerants have been proposed especially from among the fluoride compounds. One of these proposed by Thomas Midgely, Jr., is a fluoro-chloro-methane compound with a boiling point of —180 deg. F., a low degree of toxicity and a relatively low degree of inflammability.

Continued effort on the part of our larger manufacturers of machine refrigerators to produce a unit within the financial reach of larger masses of people has lowered unit prices sufficiently that eventually the number of manufacturers in the field will probably be reduced. It is of interest that none of the pioneer machines in this industry have remained in the market. The machine type mortality has been exceedingly high and a further stabilization of the history will be welcomed by both manufacturers and users.

One radically different machine has appeared in the market using water as the refrigerant and a mercury aspirator as the compressor element.

The Ice Refrigerator in 1930

In spite of the trade reports that our national consumption of block ice is still increasing annually, the ice refrigerator business has continued to decline. Some of this apparent discrepancy in reports can be explained by the large number of secondhand refrigerators thrown onto the market by the monthly sales of over 50,000 machine refrigerators. In the majority of cases, these machines replace a good ice refrigerator which, in turn, is resold at a low turnover price.

The experiments of D. K. Warner, who has proposed a radical departure to brine ice as a means of reaching the low temperatures required in household refrigeration to produce ice cubes, are being watched with considerable interest. Several test installations are being studied to determine whether the method is economically a successful substitute for machine refrigeration.

Frozen Food Development of 1930

This phase of refrigeration has attracted scientists, financiers, and the fruit and vegetable growers to a degree beyond expectations.

The Quick Frozen Food Industry will, no doubt, give the greatest impetus to the refrigeration industry of any recent development. Quick freezing must be done in less than one-half hour; such a requirement demands new designs of equipment, new provisions for material handling and new methods of distribution.

New plants have sprung up rapidly to engage in the new art. Over the eastern fish producing area, quick freezing plants have been completed for the quick freezing of fish and oysters. For the Midwest stock raising region, quick frozen meat plants have been started in the Chicago and Indianapolis area. In Georgia, two plants have been put into operation for the quick freezing of peaches. In the Northwest, strawberries are being packed as quick frozen fruits in large quantities for the eastern market. In California, a large project is in the making of handling thousands of barrels of apples annually by the quick frozen process, while, as has been indicated in the discussion on terminal storage advances, Florida is handling large quantities of citrus juices by the quick freezing process.

Distribution Major Problem

The major problem, still only partly solved, is that of economical distribution. Quick frozen foods were first packed in large wholesale barrels and packages, but the assured volume of business must be expected in small package delivery. For such delivery, the package must be carried under refrigerated conditions.

Probably the quick frozen food industry promises our greatest single change in the method of handling foodstuffs so far experienced in this century. It offers the greatest opportunity for the stabilization of the perishable food industry yet proposed.

While the year 1930 has not brought us much closer to a universally accepted theory on the physical and chemical changes involved in the quick freezing process, several clearly defined explanations of the probable reactions within the cell structure of the foodstuffs have been offered. Probably the finally accepted explanation will be a composite of several of those offered.

The magnitude of the industry is already amazingly large. Over 30 plants are in operation. The total of frozen cherries and strawberries for 1930 will probably exceed 50,000,000 lb., and frozen fish will probably equal two to three times this amount.

Air Conditioning and Cooling

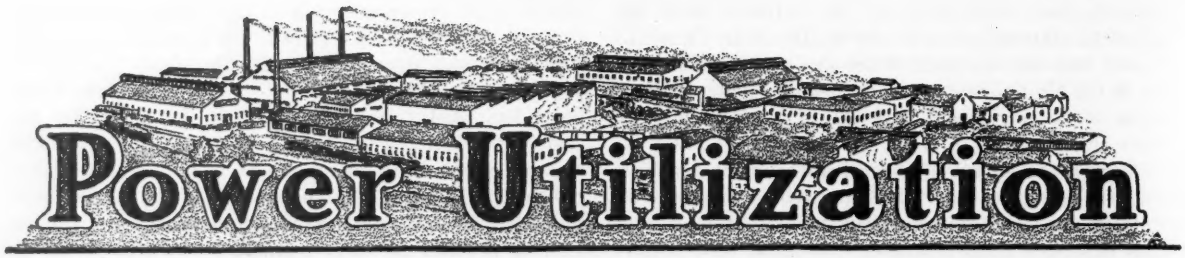
Air cooling has progressed most satisfactorily during the year. Industries and homes alike have indicated a deep interest in the possibilities of increased comfort and production under cooler summer working conditions.

Over the southern area of the United States, where long warm seasons prevail, theaters are now generally cooled by some type of refrigeration apparatus. In most public houses, it requires about one ton of refrigeration for each 15 to 30 occupants. For comparison, one ton of refrigeration will supply ice for approximately 50 homes daily.

This comparison indicates what the air cooling of homes, factories, playhouses and churches means to the industry. For therein lies an almost unlimited possibility in the expansion of the machine equipment business, auxiliary supply business and new inventions.

Manufacturers of unit cooling and conditioning units have had a steady growth in their business. Their units have generally withstood the introductory tests and have met with great favor.

The proving period is about over and there is every indication that unit coolers and air conditioners will have a rapid demand increase. The very nature of the load which they put on the compressors will bring another type of compressor demand of no small proportions.



Safeguards for Low-Voltage Electrical Supply

DUAL POWER SOURCES, AUTOMATIC TRANSFER AND PROTECTED CIRCUIT BREAKERS, TIME LIMITS, CONVENIENT INSPECTION AND REPAIR. BY HERBERT C. GRAVES* AND J. A. C. KRIPS†

DURING the past few years, many changes have taken place in the nature of the protective equipment used for electrical circuits, due to the increasing demand for: 1. Continuity of service; 2. Safety to operators and maintenance men, and 3. Overall economy, considering first cost as well as cost of installation and maintenance.

One large eastern utility engineering organization has calculated that, on a basis of overall economy of installation, the maximum size of motor which should be used on a 440 or 550-v., 3-phase service is 300 hp. A large consulting engineering organization puts the dividing line above 150 hp. In general, it would appear that motors of 200 hp. and below may economically be connected to a 440 or 550-v. bus.

Thus 440 or 550-v. motors frequently represent an important portion of the load of industrial plants, as well as power station auxiliaries. Need for continuity of voltage supply has led to dual power supply, dual buses, transfer breakers for automatically selecting a live source and even dual motors.

DUAL POWER SOURCES

Figure 1 shows a transfer breaker consisting of two motor-operated breakers, electrically and mechanically interlocked, each being fed by a separate source, which, for practical reasons, it is desirable to keep separate. The transfer breaker will immediately transfer the load from a dead source to the live source as occasion demands, so that continuity of bus voltage is assured. The seven-pole, double-throw knife switch shown in Fig. 1 is used to make a particular source the one preferred, where operating conditions may make it desirable to alternate. Time-delay being such as to ride over short-voltage disturbances.

Separation of the two sources simplifies the protection scheme as a fault on either source causes the breaker to transfer to the remaining good source. Faults on the bus cause both breakers to be locked open.

FEEDER PROTECTION

Using feeder breakers to protect motor circuits, a protective system has been devised that tends toward continuity of service and safety to operators at relatively small expense. This consists of two overcurrent features, both operating directly to trip the feeder breaker.

The first of these is an instantaneous overcurrent feature usually adjusted to operate between eight and ten times the rating of the circuit breaker, which permits full voltage starting of motors, yet assures instantaneous clearing of faults on individual feeder or motor circuits with a minimum of disturbance. This device also reduces the duration of a short circuit, and, therefore, protects life and property and reduces maintenance. It also prevents synchronous machines from falling out of step, since the duration of the voltage dip incident to short circuit is minimized.

As the second feature, a low-setting, time delay, overcurrent device, also acts directly to trip the feeder breaker. This feature has a current range of from 100 to 200 per cent of the current rating of the feeder breaker and a time delay to suit the specific service. It will cause no tripping of the breaker due to the starting current of an across-the-line starting induction motor but, will operate, if the motor in question runs on single phase or is severely overloaded, even though the overload draws a current of approximately one-third the magnitude of the starting current.

BREAKER PROTECTION

Need for protection of all live parts has led to the growth of the dead front switchboard, a construction relatively simple to develop with knife switches.

To do this well with circuit breaker panels was less simple. The problem necessitated: 1. Enclosing the breaker without reducing its interrupting capacity; 2. Permitting hand operation without openings through the door at the handle whereby explosion gases might hurt the operator; 3. Making the handle mechanism such that it permits free access to the breaker when the cover is removed; 4. Disconnecting the breaker from contact with the bus for maintenance purposes; 5. Permitting the breaker to be locked open for safety to motor maintenance men; 6. Enclosing all live parts, including bus; 7. Keeping overall cost, including first cost and cost of installation and maintenance, at a minimum.

Most important and difficult in the evolution was the development of an air circuit breaker completely enclosed in a steel box. One of these breakers and cover is shown in Fig. 2. Hand operation is performed by a rotating motion, one direction to close and the other to trip, leaving no opening at the handle for an arc to burn the operator. When the box cover is removed, no

*Engineering Manager, I.T.E. Circuit Breaker Co.
†Design Engineer, I.T.E. Circuit Breaker Co.

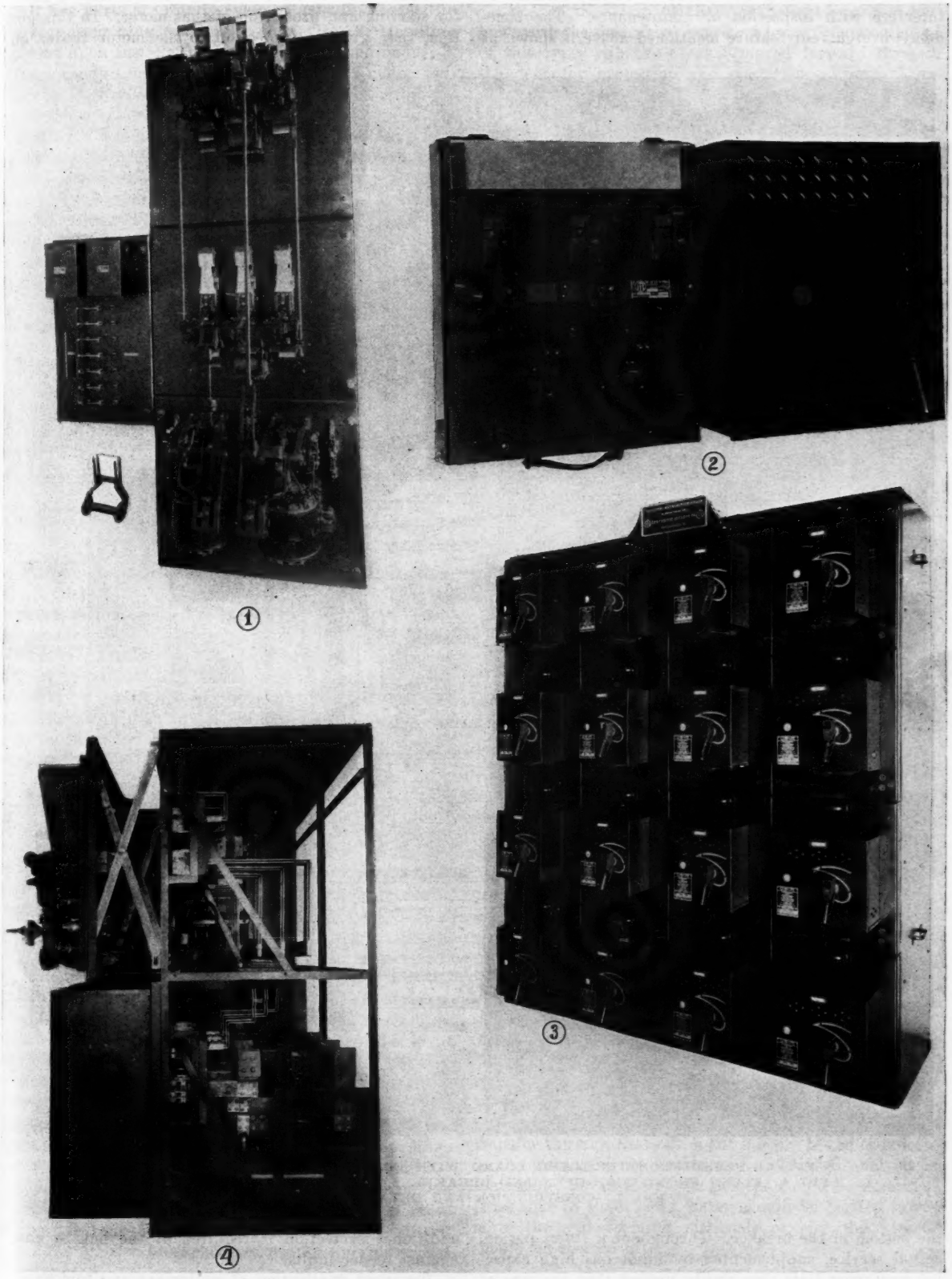


FIG. 1. THIS BREAKER TRANSFERS AUTOMATICALLY FROM A DEAD SUPPLY SOURCE TO A LIVE ONE
FIG. 2. BREAKER IS ENCLOSED WITH OPERATING HANDLE ON THE COVER
FIG. 3. BREAKERS GROUPED FOR FEEDER AND MOTOR PROTECTION GIVES ECONOMY
FIG. 4. REMOTE CONTROL BREAKERS MAY HERE BE DISCONNECTED FOR MAINTENANCE WORK

part of the operating mechanism or handle remains to interfere with inspection or maintenance. The time-delay, overcurrent feature mentioned above is shown at

Such breakers are frequently located near a motor, for starting and protection of that motor. In this position, they give no protection to the motor feeder and

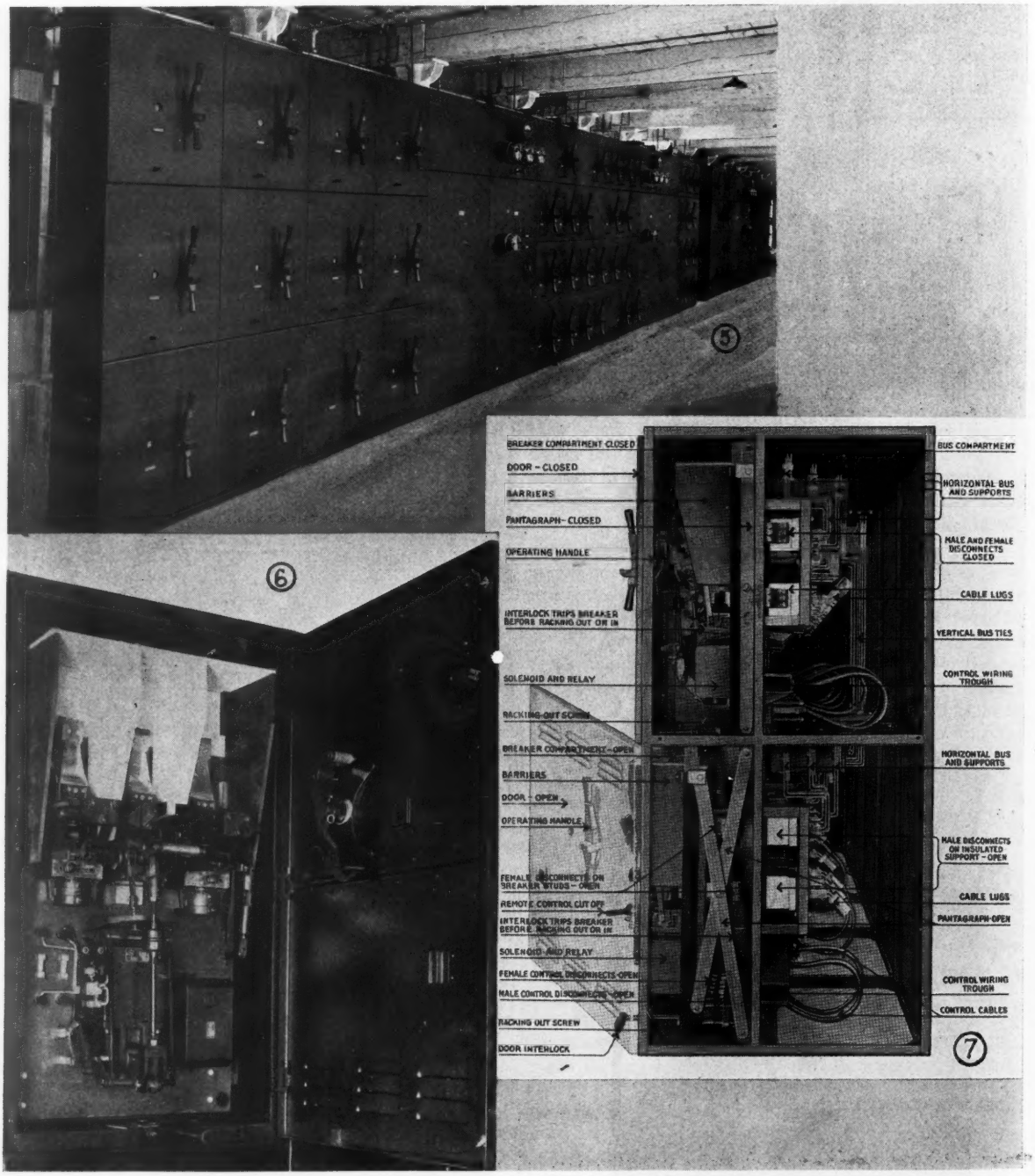


FIG. 5. FLUSH FRONT BREAKER BOARD WITH DOORS FOR ACCESS TO BREAKERS
FIG. 6. FLUSH FRONT DOOR OPEN AND BREAKER MOVED OUT FOR ACCESS TO PARTS
FIG. 7. CONSTRUCTION AND DETAILS OF FIG. 6

the bottom of the breaker. Throughout a 10-yr. period, actual service, supplemented by numerous high capacity rupturing tests, has amply proved that any arc of the voltage under consideration may be ruptured quite as effectively within a properly designed steel enclosure as in open air.

additional protection is required at the bus to guard against feeder faults.

To avoid duplication of equipment and bus hazard, the arrangement shown in Fig. 3 was designed. Motor feeders are supplied directly from this distribution group, the arrangement having advantages as follows

1. All live parts are totally enclosed, avoiding hazard to life and improving continuity of service; 2. Handling incident upon installation is reduced to a minimum; 3. Liberal conduit space in the rear facilitates motor connections; 4. Feeder faults are isolated from the bus by the feeder breaker with no other loss of load; 5. The arc caused by a breaker opening is confined and can cause no damage to life or to other circuits; 6. By removing breaker covers, the breakers may be inspected and maintained; 7. Breaker handles may be locked to trip position to permit work to be done on the feeder with safety; 8. Floor space is economized as compared to open switchboard.

This group has certain limitations chiefly because of the difficulties to be overcome during inspection and maintenance. Work on breakers must be done with breakers connected to the bus, which requires extra precautions. To replace a breaker, it must be disconnected from the bus while the bus is hot, or else wait until the bus may be conveniently killed. Also, motors must be started by manually closing a breaker at the switchboard. Finally, this type can not be backed up against the wall.

Remote Control and Removable Breakers Overcome Previous Limitations

Further progress overcame the above limitations, Fig. 4 illustrating a distribution group on which are mounted remote control breakers, which may be operated either manually or from a convenient remote point. Breaker connection to the bus and feeder are made through separable contacts, the breaker base being mounted on the steel panel, which in turn is mounted onto the switchboard by a pantograph mechanism, so that the breaker may be moved in or out to make or break the connection with the bus.

Breaker motion is obtained by means of a screw mechanism which insures that the breaker can never vibrate into or out of contact. Maintenance work on the breaker can be done readily and safely, since live parts are never exposed. The breaker is bolted to the steel panel, hence can be easily exchanged or replaced. Flexible control cable permits the remote control breakers to be operated, while out on the pantograph, for test and inspection.

Suitable interlocks between the breaker and the structure, prevent current being broken anywhere except on the arcing contacts of the breaker, also the possibility of closing the breaker except when the main separable contacts are entirely in mesh with or entirely disconnected from buses with suitable electrical clearance between phases.

This board may be mounted against a wall, since feeder connections may be made through the openings in the steel panels when the breakers are removed.

Limitations to this arrangment are that no meters can be mounted on the front of the boxes, boxes must be removed from the breakers for inspection and a board with different size breaker boxes has an unsymmetrical appearance.

Next is the development shown in Fig. 5. Removable swinging doors carry the handles formerly mounted on the boxes, the breakers being included in the frame. This board has not the separable contacts.

Most of the latest installations include separable contacts with the flush front board. Figure 6 shows a board of this type with the breaker moved forward through the door for inspection and operation. Figure 7 explains the working parts of this group.

First cost of equipment of this type, as compared with an open type of board, is found to be approximately 20 per cent higher but, as an offset against this, the steel clad board is easier to install. It is necessary only to bolt the sections on channels previously prepared and run in the cables to the main and feeder breakers.

Proper selection of protective equipment will vary with local conditions. Some operators prefer overload features to give an alarm only, instead of clearing the circuit. They want the motor to continue running and even to burn out rather than to drop the load unnecessarily. Others wish to protect the motor and even cut out the overload features during the starting period, so that these may be set just above the normal load current. Conditions vary between these extremes.

Belt Transmission Essentials

I have before me a photograph showing pulleys poorly alined because the belt projects over the edge of the pulley by an inch and a half or two inches, i.e., with an "overhang." Also the belt makes poor contact with one of the pulleys. Such conditions are hard on the belt and drives are inefficient.

That poorly designed and alined belt drives last as long as they do merely serves to emphasize how hardy and tough leather belts actually are. Under favorable conditions, a first-class leather belt will last 30 yr. or even more. Some leather belts have been in continuous service for more than 50 yr. and are still going.

Another point to be avoided is use of narrow belts. This is treading on dangerous ground. Under modern service conditions, it is better to use wide belts rather than narrow ones. Where narrow belts are used, they are often overstressed in service and fail prematurely as a result. A first-class belt drive will be efficient and economical. By first-class belt drive I mean a drive that is properly alined, with no overhang, practically no slip and no overstressing. Wide two-ply belts are better wherever practicable. True, single leather belts can be used on smaller pulleys than two-ply and they cost less but they are less dependable than double belts.

Newark, N. J. W. F. Schaphorst.

Practically all natural or ground water contains solids which when heated deposit scale. When this water is used in water jackets of engines and compressors, a deposit is gradually built up and the heat transfer through the wall is cut down. If the chemicals in the water are not known and a chemical analysis is impossible, the inside of the jackets should be examined from time to time. Bad water should be treated to remove the scale-forming materials or else the jackets should be cleaned often.

It has been found that certain 9 in. thick refractory air-cooled walls exposed to a furnace temperature of 2500 deg. F. on one side will transmit about 2000 B.t.u. per sq. ft. per hr. to the circulating air.

Compressed Air for Forge Hammers

Suitability of Air, Amount Needed and Receiver Volume. By C. W. Gibbs

COMPRESSED AIR as a medium for operating forge hammers is now receiving more attention than ever before, partly due to the greater attention which forge shops in general have been paying to their power costs and similar economies, partly because of more extensive use of central station power. While a number of moderate size plants have been using air continuously for 10 or 15 yr. and would not consider returning to steam, not every forge shop can be changed over to air operation economically.

Suitability Depends on Plant Conditions

Forge shops making parts for the automobile industry, for example, are as a rule working with large orders for a single part, for which production can be scheduled accurately and which must be produced at minimum cost. Die changes are infrequent and it is the rule rather than the exception, as far as the writer's observation goes, that several operations are completed on the material with one heat. Furnace equipment is designed for the job to be done, automatic furnaces being sometimes used, which time the delivery of the material and keep the force operating at the most economical speed. These shops are usually organized on a 16 to 24-hour basis, and their standby time is small. Such plants can, as a rule, be more cheaply operated on steam than on air because of the high load factor maintained on the boiler plant, which can therefore be well made efficient plant and can produce steam cheaply.

For the sake of distinction, the second type will be called a semi-production plant. Operations are usually in one shift and on small lots. Due to the frequent changes in the work which must be done on a given hammer, it is uneconomical to install the most efficient furnaces for each job and it is infrequent to have more than one hammer working on a single piece at one heat. Because of single shift operation, the standby losses on steam are a fairly large percentage of the total energy consumed and the load factor on the boiler plant is decreased materially, which increases the cost of steam for productive purposes. This type of plant, on analysis, will usually show economy when operated with air instead of steam but a careful analysis is required and the relative costs of steam and electric power must be considered.

Usually, the third type of shop is a repair or a jobbing shop, similar to railroad and heavy machinery repair plants, where flat die forging hammers are used. In such a plant, the load factor is low and the standby losses are even higher than in the semi-production shop. This type of installation can generally be profitably changed over to air operation.

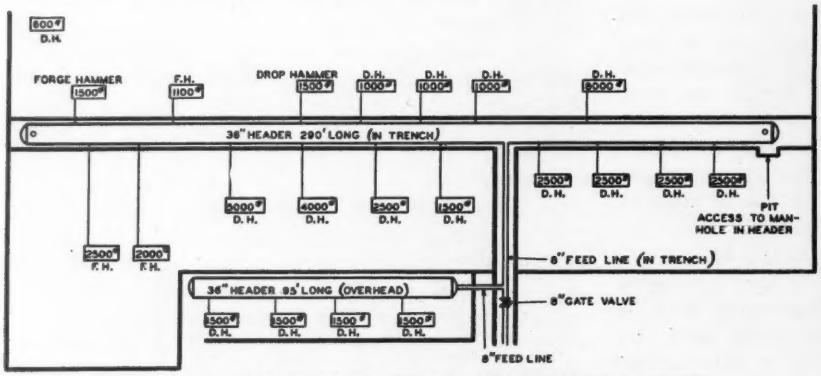


FIG. 1. AIR HAMMER PIPING AND HEADER LAYOUT

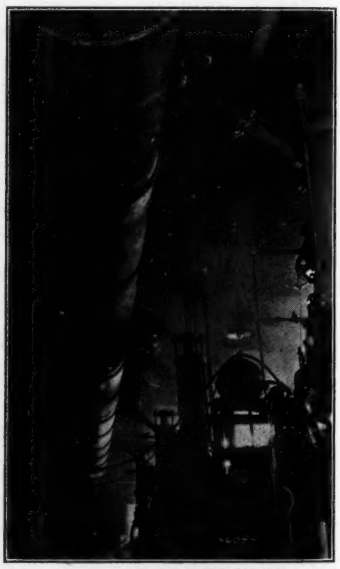


FIG. 2. 36-IN. OVERHEAD AIR PIPE

In any conversion job, the question of whether steam for other uses can be eliminated must also be considered.

Air Needed

Air necessary to operate a forge shop depends on a number of variables, one being shop procedure, which is never the same in two shops. Probably the best basis for estimating the amount of air required is the pounds of falling weight. This is by no means accurate although, for most plants, it averages up in the long run to a satisfactory figure. No set rule can be given for the amount of air required but, as a rough figure for preliminary estimates, use 16 cu. ft. a min. per 100 lb. of falling weight for plants averaging three or more hammers and 20 cu. ft. per 100 lb. of falling weight for plants with less than three hammers. The amount may vary, however, from as low as 5 cu. ft. per 100 lb. falling weight to as high as 30 cu. ft., depending upon the method of operation of the hammers, the load factor of the individual hammers and the percentage of the installed capacity which is running at a given time.

Data for Comparative Analysis

In order to estimate with even reasonable accuracy the air required for a forge shop, the following data should be obtained, by actual observation wherever possible as hearsay data are usually unreliable:

1—List each hammer together with its rated falling weight and type (whether drop forge hammer or flat die forge hammer) and the name of the maker.

2—Number and size of hammers operating each day, giving the average and the maximum.

3—Hours per day that each hammer is in operation. This is crew hours and not the actual hammering hours.

4—For each hammer, number of effective striking blows and number of oscillating strokes per minute. The per cent of the day working on material and the per cent of the day idle or waiting for heats should be given.

5—Type of product.

6—Amount of steam now used including the maximum, the average and standby steam when known. Any and all information relative to steam consumption, steam costs, division of steam costs from month to month and day to day will be of great assistance. State whether the steam consumption figures were obtained, by meter, by cost of coal or by guess.

7—Capacity and type of boiler plant.

8—Is steam used only for the forge shop or are there auxiliary uses?

9—What is the operating pressure actually found *at the hammers* throughout the shop?

10—What is probable net cost of power per kilowatt-hour, including demand charge?

11—Sketch of shop layout and possible location of compressors showing approximate distance between, if possible.

Analysis should be made of present or probable cost of steam operation and of cost of power for air operation including transmission loss in the air lines. Also, if steam must be furnished for other uses, the cost of such steam supply must be added to the cost of air operation of hammers.

An an indication of what may be done along the line of conversion, the following notes on the conversion of the Phillipsburg shop of the Ingersoll-Rand Co. from steam to air will be of interest.

At the present time, 22 hammers, 18 of them from 8000 to 600 lb. being drop hammers and 4 of 2500 to 1100 lb. being flat die, single frame hammers, are in use. When operating under normal load, 11 to 14 of the hammers are in operation, totaling about 30,000 lb. falling weight. To operate these hammers for a year costs about $45,000 for steam at 50 cents per 1000 lb. of steam. It is estimated that these are operating with air on less than 4000 cu. ft. per min., although it has not been possible to check this on the total plant as yet. Meters will be installed soon and accurate figures obtained. It is estimated that the use of air instead of steam will save better than $15,000 a year, at present power cost.

On steam the average pressure in the forge shop was 128 lb., while air operation is entirely satisfactory at between 90 and 100 lb. pressure.

One important advantage already discovered is that the operators find air operation more satisfactory than steam both from the standpoint of the hammer action and because no hot water is dripping on them and on the dies. This snappier action has been obtained in spite of the fact that the pressure has been reduced.

Figure 1 shows the simple layout of piping. This provides for about 400 ft. of 36-in. hammer welded pipe. The headers are located so as to provide receiver volume close to the hammers, which is essential because, when a hammer is operating, it requires a lot of air quickly and, if the pressure is not maintained, the most effective blow will not be delivered. The amount of receiver volume which should be installed is rather indeterminate and will depend largely on the layout of the individual shop. Also the possibility of peaks in the demand for air and the relative variations in the size of the hammers, will be determining items.

Importance of ample receiver capacity can be easily shown. In the layout of Fig. 1 there is 49,200 lb. of falling weight which at 16 cu. ft. of air a minute would call for 7776 cu. ft. a min. with all hammers working. As 4000 cu. ft. a min. is found to be the average supply needed, a compressor of say 5000 cu. ft. would be provided to allow for peaks.

If, by chance, all hammers started working for one minute, the deficiency would be 7776 — 5000 = 2776 cu. ft. for that minute. Assume that pressure might be allowed to drop to 80 lb. from the 100 lb. usually maintained. Then a receiver would be needed to furnish the equivalent of 2776 cu. ft. of free air. For a receiver volume V, the free air in the receiver at the start would be $V \times 114.7 \div 14.7$; at the end it would be $V \times 94.7 \div 14.7$; the difference would be $V \times 20 \div 14.7$; this difference is 2776 cu. ft., or $V \times 20 \div 14.7 = 2776$.

Then $V = 2776 \times 14.7 \div 20 = 2040$ cu. ft. As the volume of the 385 ft. of 36-in. pipe is 2695 cu. ft., the air needed will be easily supplied without excessive drop.

Hammers should be overhauled after they have been operating on steam and are to be changed to air, so that they will start out with the proper fits for air operation. Wear in a steam hammer is considerably more than in an air hammer because of the higher temperatures involved and the difficulty of lubrication, due to water which condenses in the line and the hammer cylinders. Initial fits on air hammers can be closer than on steam hammers by a considerable amount and all air valves should be lapped into their cages rather than given the clearance of 0.004 to 0.006 in. which is usual with steam. Frequent inspection and repair of these valves will save a lot in air capacity required. Complete overhaul of each hammer in our shop has been made as it was put on air.

On steam it is necessary for a drop forge hammer to oscillate in order to keep water out of the cylinder. An air hammer need not oscillate but, so far, no economical means of eliminating this oscillation has been devised. Attempts to get hammer builders interested in this have brought few developments to date. A number of ideas are being evolved, however, and in time a more suitable air hammer will undoubtedly be put on the market. Elimination of oscillations in an air hammer will save 40 to 50 per cent of the air used in the average shop and proportionate amounts in other shops, depending on the size and operating conditions.

Summarizing the above, air operation of forge shops is most economical when the load factor is low and no steam is needed for other work. It is impossible to give

a definite fixed rule for estimating forge shops, hence every job should be individually analyzed. The old figure of 16 cu. ft. per 100 lb. of falling weight is good for average preliminary estimates, but should not be assumed to be the true figure for every job. The actual amount of air used will depend on many factors which require study before final determination of the layout.

Motor Drives Paper Machine

CLOSE REGULATION WITH PUSH BUTTON CONTROL AND D.C. MOTOR. BY R. R. BAKER*

IN LINE with a program covering plant expansion and improvement, the Champion Coated Paper Co. of Hamilton, Ohio, recently electrified the drives for ten of its paper machines, which were originally driven by noncondensing steam units. By increasing the steam pressure and temperature, centralizing the power generation and electrifying these 10 paper machines, the mill was able to improve its operating economies.

Paper machines were equipped with the latest type of single-motor electric drives supplied by the Westinghouse Electric & Manufacturing Co. The electrical equipment for each machine was specified as interchangeable, one complete drive being furnished to serve as a spare for any machine. Each drive includes a 220-hp., adjustable speed 1000-r.p.m. maximum, 250-v. d.c., bracket type motor with bedplate and outboard bearing for belted service, to drive the variable speed lineshaft; a 175-kw. synchronous motor-generator set with direct-connected exciter, 250-v. d.c., 3-phase, 60-cycle, 2200-v. a.c. for supplying power to the adjustable speed motor, also complete control equipment. The control provides electrically-operated, full-voltage starting equipment for the synchronous motor of the motor-generator set and automatic control for the d.c. motor and generator.

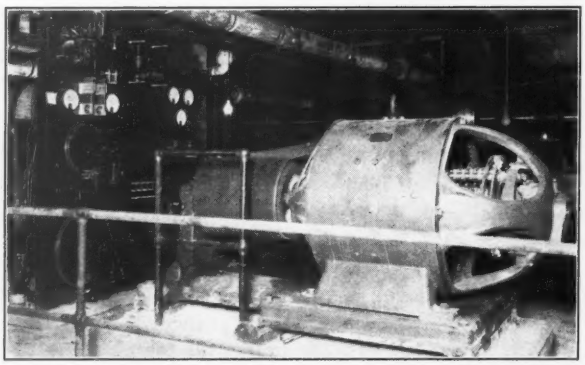


FIG. 1. MOTOR IS BELTED TO LINE SHAFT WHICH DRIVES THE ROLLS

Direct-current control is arranged to permit starting, stopping and adjusting the speed of the main d.c. motor from a master push button station, which is located at a convenient position near the paper machines. Each machine is provided with an electric tachometer to indicate the speed at which it is being operated and the control is of the pre-set speed type, which, on starting up, automatically serves to return the motor to the speed at which it was operating prior to being shut down. The speed control rheostats are motor operated, which assures that all speed adjustments can be made gradually and without interfering with the paper machine production. These rheostats were designed to give equal percentage speed increments per step and have a total of 200 speed points. This arrangement provides very close speed adjustment over ranges of 5.3 to 1 or 3.3 to 1, each step of the speed control rheostat giving approximately equal percentage change in paper weight.

Close speed regulation of the paper machine is essential in obtaining a high-grade product of uniform weight. To permit maintaining uniform speed, each paper machine is equipped with the latest type of speed regulator furnished by the Westinghouse Co. This operates by armature voltage control through a motor-driven rheostat in the main generator field circuit. These regulators are of the carbon pile type, exceedingly sensitive in operation and rugged in design, permitting of extreme accuracy yet requiring minimum attention. With this type of speed regulating equipment, uniform operating speed of the paper machine is assured over the operating speed range regardless of load changes or frequency variation in the power supply.

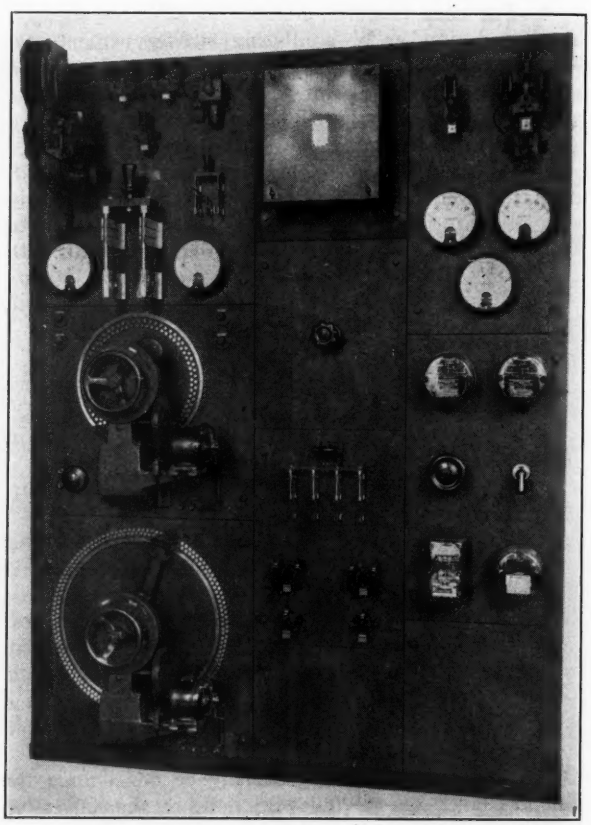


FIG. 2. CONTROL BOARD WITH MOTOR-OPERATED RHEOSTATS, CARBON PILE REGULATOR AND ELECTRICAL STARTING FOR SYNCHRONOUS MOTOR

By this method older paper mills may be modernized, taking full advantage of increased paper machine speed and speed range, improved paper machine speed regulation and control, and improved operating economies effected through higher operating steam pressures and temperature and improved prime mover efficiencies.

*Industrial Engineer, Westinghouse Elec. & Mfg. Co.

Ideal Electric Introduces Line of Unit Type Motors

IDEAL Electric and Mfg. Co. of Mansfield, O., has developed a complete new series of electric motors known as the unit type motors.

These motors present many new design features of considerable interest. By placing the motor feet on the bearing brackets, all load shocks and strains are carried directly to the motor support. Shock loads or vibration will not affect the live elements or weaken the assembly of this motor. Since the bearing brackets support themselves, the only mechanical load on the stator is the motor torque.

When the front end bracket and stator are removed, the pulley end bearing bracket remaining bolted to the base will still support the rotor and gear, pulley, or other connection to the driven machinery. This allows cleaning and examination in much less time than usual and without disconnecting the drive gear or pulley.

These motors are built with standardized units (rotors and stators) which are perfectly interchangeable for all types; thus standard horizontal motors, shell type motors, flange type motors, vertical motors, special applications of "built in" motors requiring only the active elements, etc.—all take the same rotors and stators. These same standardized rotor and stator units are used to build open type motors; splash proof motors, drip-proof motors, totally enclosed fan-cooled motors with running seals or stationary seals; explosion proof motors; shaftless motors, etc.; in short, there is no limit to the mechanical combinations possible through the use of these standardized rotor and stator units.

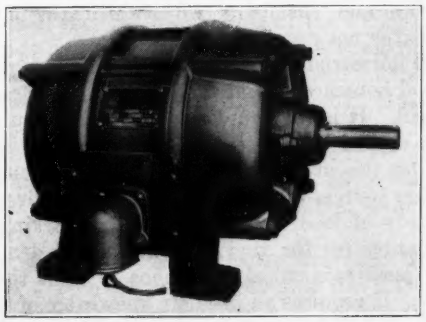


FIG. 1. A 5 HP. 1800 R.P.M. BALL BEARING "IDEAL" UNIT TYPE MOTOR

Interchangeable ball, roller or sleeve anti-friction bearings are supplied as standard because of their many advantages. The ball and roller bearings are of the cartridge type, so constructed that the motor can be taken down without dust or dirt entering the bearing. This assures long and continuous operation. Zerk fittings with automatic seal are used to supply grease under pressure.

Sleeve bearing housings are of a design that can be rotated for wall or ceiling mounting without removing the bearing brackets and these sleeve bearings can also be replaced without removing the bearing brackets or dismantling the motor. The bearings are centrifugally cast with a hard glazed finish.

The stator core is reënforced by eight steel bars (ribs) welded directly to steel rings (stator heads) at each end of the core. This forms a welded steel cage which is ground to fit the two bearing brackets—the most simple and rugged construction possible. The stator slots are skewed in relation to the rotor slots to assure quiet operation, lively acceleration, and absence of dead points on starting position. The corresponding field structure of direct current motors is similarly designed as a unit to take the standardized bearing brackets.

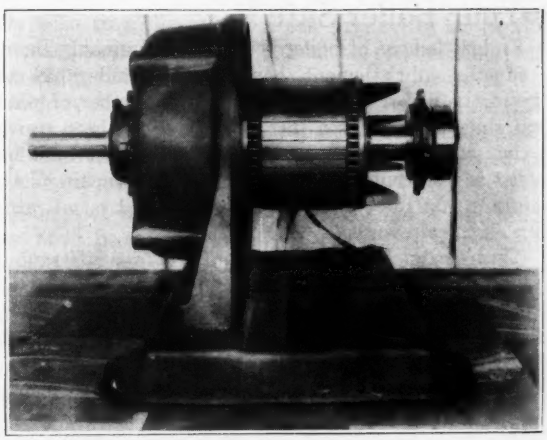


FIG. 2. SHOWING PULLEY END BEARING BRACKET SUPPORTING ROTOR WITH STATOR REMOVED

Insulation of motor windings is of utmost importance and has received careful attention. The slot cell insulation is a tough fibrous material possessing heat resistant qualities and great dielectric strength and especially developed for this motor. The stator coils are wound with enameled wire, cotton covered. Varnished duck is used for phase insulation, an exceedingly tough material with excellent insulating properties. Standard insulation (for 220 v.) consists of three impregnations with a special insulating compound. The stator is thoroughly dried and baked before and after each impregnation. Additional impregnations are given for special requirements. Direct current field and armature windings and wound rotors are similarly insulated and impregnated.

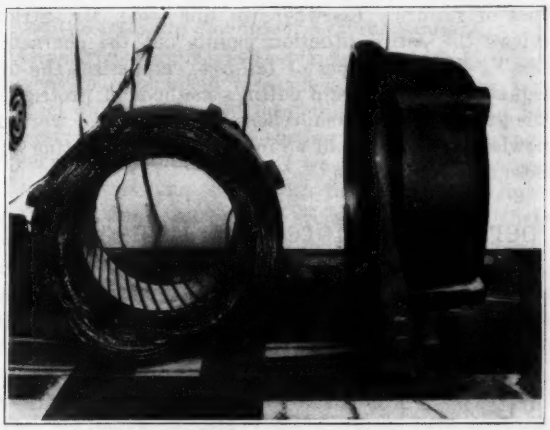


FIG. 3. THE STATOR AND OTHER BEARING BRACKET OF THE 3-HP., 1800-R.P.M. MOTOR SHOWN IN FIG. 2

They are furnished in sizes from ½ to 200 hp.

Editorial Comment

Is Your Boiler Safe?

Embrittlement of boiler steel, more commonly known as caustic embrittlement, has caused considerable concern in the power plant industry for a number of years. That embrittlement is a fact has not as yet been proven to the satisfaction of some individuals, most of whom persist in referring to such failures as "cracking" and maintain that these cracks are caused by physical rather than chemical causes.

Nevertheless the early work of Professor Straub in this country and certain investigators in Germany was sufficient to have the A.S.M.E. Boiler Code Committee adopt certain feedwater recommendations as early as 1925. In spite of these precautionary recommendations, costly boiler failures have taken place during the past five years.

The growing importance of high pressures made more definite data imperative in the central station field. The recent work of Straub fulfils this need and presents evidence which is hard to contradict. In the absence of supporting data, even the opponents of the embrittlement theory must admit that the wise course is to adopt the precautionary measures recommended by Straub in his latest work.

Even among metallurgists, the phenomenon of embrittlement is not well known and is often confused with corrosion cracks. Nevertheless embrittlement presents characteristics which distinguish it from other types of failure. Elsewhere in this issue, Mr. Straub reviews the entire situation, points out the characteristics of different types of failures, emphasizes the distinguishing features and outlines methods of protection. This article gives a comprehensive picture and working knowledge which should be invaluable in combating this phase of boiler failure.

Operation Is More Than Housekeeping

As power plant equipment has become more efficient, it has made use of more principles involving a knowledge of physics, chemistry and metallurgy than were involved in the simple plant of ten or twenty years ago. Unfortunately the idea still prevails in the minds of many industrial and building plant owners that a plant which is kept clean, orderly and in repair is being operated at its highest efficiency. On this basis the tendency would be to employ, as plant operators, men who were essentially good janitors with sufficient mechanical sense to make minor repairs but only by chance would they possess the knowledge and ability to analyze the conditions which affect efficiency, economy and continuity of service of the plant.

Good housekeeping is essential in every plant. Clean machinery, floors, walls, windows, ceilings, piping have an extremely desirable effect on the class of work done in a plant. With tools and supplies kept in conveniently located racks and shelves, valuable time is saved when most needed. Keeping nuts and screws tight, packing glands and pipe fittings leakless, bearings adjusted and properly lubricated, would all come under the classification of good housekeeping and are positively essential to the efficient operation of a power plant but they do not require a technically trained engineer.

Twenty years ago many of our best operating engineers came to the chief's position through the machinist's trade and a natural ability to handle men. Unquestionably an expert machinist would be well qualified for making repairs to equipment, running pipe lines and installing shafting and his ingenuity in running a lame plant, in many cases, has been truly marvelous. His limitations, however, became manifest with growing use of electricity, particularly alternating current, and the development of instruments based upon principles of physics and chemistry with which the machinist tradesman is not necessarily familiar.

Good industrial power plant operation today is more than good housekeeping, it is more than maintenance of equipment. It is the supplying of all the required services as needed at a cost which will justify the owner in making the investment in his plant in competition with other sources of the services. This requires a complete study of load conditions and the working out of heat balances for the varying conditions and maintaining the most economical conditions to meet these heat balances. It requires an intimate knowledge of the fuels available and ability to burn them at highest efficiency. It requires a study of feedwater and its treatment. It requires a knowledge of thermodynamics to work out the bled steam and power load division on a turbine. The principles of electrical equipment must be thoroughly understood. Such problems as these are technical and the significance of their proper solutions can scarcely be comprehended by a non-technical man before the results of application are available.

Modern power plant machinery, instruments and practice are the results of scientific discoveries, research and application and, as each plant has problems of an individual nature, the man in charge of operation must not only supervise the housekeeping and maintenance of the plant but carry on investigations that will result in continually reducing costs.

Records for Posterity

Not long ago a collection of 10,000 photographic prints made over a period of about 20 yr. by M. Atget in Paris, attracted considerable attention shortly after his death. The photographer was poor and unknown. He worked with a camera that would give good results only in the morning when the air was clear. He attempted no artistic effects but took pictures of buildings, shops, postmen, policemen, wagons, automobiles and similar commonplace subjects. The pictures have one chief merit; they show every detail of the principal subject. As art they are negligible; as historical and

sociological documents they are priceless. They show every detail of countless commonplace objects that everyone takes for granted and over a period of years they show changes and developments in those details of which no other record is extant.

Even if it is admitted that such detailed records have little actual monetary value to the general public, they at least have interest. And for the historian they possess the highest value. It is as if someone should go into the streets of New York and Chicago and photograph street cars, taxicabs, fire hydrants, public buildings, traffic lights and all the myriad commonplace details of our daily life, thus securing data on them that could otherwise be preserved only by long descriptions or drawings.

And why shouldn't this very thing be done purely for historical and scientific purposes? Data on actual physical details of present-day equipment, costumes, buildings, bridges, methods of transportation should be interesting and valuable for future historians and economists. Never before in the history of the world has there been such an accretion of material things as in the United States today. True, we have museums designed for the preservation of many important technical devices, such as the Museum of the Peaceful Arts, the Benjamin Franklin Memorial and Franklin Institute Museum, the Museum of Science and Industry, the Ford Museum at Dearborn, the National Museum in Washington and similar institutions. But our observation is that such museums often do not contain many of the commonplace objects about which historians, economists and scientists may wish information 50 or 100 yr. from now.

H. L. Mencken suggested some time ago that any individual who could make a collection for a few years of the various circulars, catalogs and bulletins that go through the mails, describing every conceivable product, method and apparatus on the market would be rendering a valuable service. The mass of this material is tremendous, of course. Just consider the amount of printed matter sent through the mails relating to the power plant field. Over a period of three or four years, this material alone would fill a good-sized library.

Certainly a large collection of photographs and catalogs showing details of the rich and varied physical equipment of modern life might well be included in some of the museums referred to above and it is to be hoped that the directors of those institutions have already considered doing so. If the idea does not fit in with their present plans, possibly some governmental agency could undertake the job. At all events, it appears to be worth while for somebody to do it.

Dual Purpose Lighting

For several years great interest has been displayed in the various forms of ultra-violet light equipment which has been made available to the public. Quartz mercury arc lamps, extremely potent radiators of ultra-violet radiation, have been used by physicians for therapeutic treatments for many years but it was only recently that lamps of a similar nature safe for public use were made generally available. The first of these were usually carbon arcs and, while they produced intense visible illumination, the quality of the invisible rays was largely a matter of faith. It was perhaps well, that many of these lamps were little if any more effective in ultra violet production than ordinary lamps, for ultra violet radiation when not used intelligently may be extremely dangerous.

Development of these lamps, however, served to stimulate interest in the biological effectiveness of ultra-violet radiation with the result that all the latest efforts have been in a direction toward producing lamps that stimulate sunlight. We all seem to realize inherently that sunlight is a health building force; hence, if it is possible to develop a lamp which will produce light having all the characteristic properties of sunlight, the field of the illuminating engineer will be extended far beyond its present boundaries.

Lamps of this kind are already available and, while they have been sold primarily for purposes of home "light" treatment, they are beginning to be considered as sources of general illumination and we know of at least one installation where these lamps have been so utilized.

Here is an immense field and there can be no question that the illuminating engineer of the future will design lighting installations, with the view of not only enabling us to see but also of keeping us healthy. From such artificial sunlight, no less benefit is to be expected than from mid-summer sunlight—much more in fact than is obtained from summer sunlight in smoky cities and from winter sunlight everywhere in middle and higher latitudes.

Particularly in industry, where workers are required to spend most of the daylight hours indoors and in offices where the biological effectiveness of natural light is practically lost, this type of lighting will prove of immense benefit. Fortunately, there are wide limits which make it possible to produce artificial sunlight as safe and practicable as outdoor natural sunlight.

Aside from its biological advantages, which alone are sufficient to recommend it, artificial sunlight may have an effect on the design of our buildings. Daylight has carelessly been accepted as costing nothing. Long ago, however, from studies made it was shown that the cost of daylight was comparable with that of artificial lighting for the single purpose of seeing. Of course, there is no intention to eliminate windows from our houses. These are needed, if for no other reason, to "let vision in," but there are many instances where windows could be dispensed with advantageously. Industrial buildings are often confined to one floor with costly roof construction which cannot be justified by a comparison of artificial and natural light on a basis of cost and satisfactoriness. Windows are placed in the upper stories of department stores, wasting display and shelf room, while artificial lighting must be operated all day long. The waste of ground area, cubical content, rental areas, the heat losses, the cost of maintenance and other factors are endured with little result in lighting.

When "dual purpose" lighting becomes more general, there will, no doubt, be a gradual change in our concept of the requirements for natural illumination and windows will be used only where it is necessary for vision and perhaps to produce certain architectural effects. Certainly windows will no longer be used just because they have always been used.

POWER WEEK

Midwest Power Conference Fuels Section A. S. M. E. Power Engineering Exhibit

PROGRESS as exemplified at the Chicago Power Show will result in an understanding of those things that power engineers seek regarding new equipment and how it can be applied. A liberal education is in store for those attending.

Ramifications in utility and industrial work offer many an opportunity for those in the field of power. Not only has equipment been developed to effect large savings over older forms but most of the newer equipment gives better security to operators, reduces hazards and affords greater understanding of the operations. Many old plants could, at small expense, afford to make changes to give better security to operators and at the same time effect remarkable savings.

With changed conditions generally throughout the country, opportunity to make better showings and initiate new ideas is foremost in the minds of men who do things.

To rub shoulders with others in the same field is a big advantage, often leading to a better understanding and quick solution of problems.

Midwest Power Conference

During the same week as the Chicago Power Show, two meetings of national importance will hold sessions. The Fifth Midwestern Engineering and Power Conference will have sessions on Power Economies, Electricity, Refrigeration, Prime Movers, Metallurgy, Water and Civil Engineering subjects.

Tuesday noon a luncheon meeting will consider the Effect of Power on Modern Civilization, with President H. W. Fuller in the chair. Papers will be presented Tuesday afternoon, Feb. 10, C. F. Hirshfeld, presiding, by A. H. Kehoe on Balancing Plant Investment with Operating Cost, by H. W. Eales on Advances in Electrical Distribution, by John M. Drabelle on Commercial Distribution of High-Pressure Steam. Tuesday evening, Alvin H. Baer presiding, will take up Refrigeration in Air Conditioning by Willis H. Carrier and Central Station Refrigeration by George Horne.

Wednesday morning, with Alex D. Bailey presiding, the session will include Trends in Steam Turbine Developments by Professor A. G. Christie, Reciprocating Engines for Higher Pressures by J. F. Ferguson, Combustion Engine Design and Practical Applications by H. F. Shepherd, Propeller Type Water Turbines by L. F. Harza.

At the luncheon meeting, C. C. Whittier, chairman, L. W. Spring will speak on High-Temperature Metals for the Power Plant.

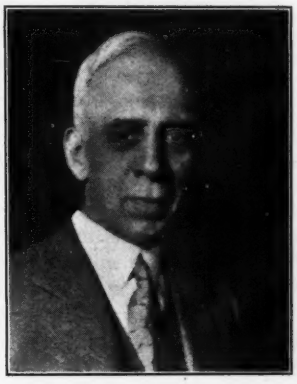
In the afternoon, R. F. Schuchardt will preside and papers will be presented on Power for Pumping Oil and Gas, by A. E. Harnsberger, on Electric Arc Welding by

IN CHICAGO

John Hunter
Vice-President,
Midwest Power Conf.

K. A. Auty
Treasurer,
Midwest Power Conf.

G. E. Pfisterer
Secretary,
Midwest Power Conf.



H. W. Fuller
President, Midwest Power
Conference

W. J. Wohlenberg
Chairman, A.S.M.E. Fuels
Division

A. D. Blake
Secretary, A.S.M.E.
Fuels Division

W. H. Zorn, on High-Voltage D.C. Transmission by C. W. Stone.

On Thursday morning, Professor F. G. Straub presiding, the papers will be Pretreatment of Boiler Feed Water by S. T. Powell, Evaporator Practice by F. S. Collings, Concentration Control of Boiler Water by H. S. Whiton.

In the afternoon, Major R. W. Putnam presiding, Geology and Reservoir Power Plants will be discussed by Dr. M. M. Leighton and Engineering Features of the Chicago Subway by Major R. F. Kelker and Robert Ridgeway.

Fuels Meetings

The Fourth National Fuels Meeting has also arranged an attractive program covering the field of fuel burning and utilization.

Wednesday afternoon, Feb. 11, will have papers on Refinery Waste Fuels in the Steam Plant by H. J. Klotz, Fuel Utilization Economics by A. L. Brown, Dehydrating Low-Grade Coal by Dr. Max Toltz.

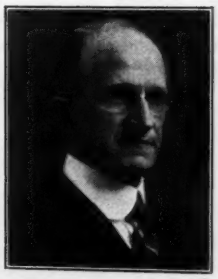
At the evening session, T. A. Marsh will speak on Developments in Small Stokers, C. A. Cornell on Utilization of Anthracite Coal, W. D. Edwards on Converting Small Coal Furnaces to Gas Firing.

On Thursday morning will be considered Slag Tap Furnaces by A. L. Baker and Pulverized Fuel Firing Developments by H. Kreisinger.

At luncheon A. C. Fieldner will speak on Preparation and Use of By-Products from Bituminous Coal.

In the afternoon, E. H. Tenney will discuss Effect of Fineness of Pulverization on Boiler Efficiency, N. Artsay will speak on Radiation in Boiler Furnaces and

A. E. Grunert
Chairman, Papers
Comm. Fuels Div.



C. S. Gladden
Vice-President,
Midwest Power Conf.

W. F. Davidson on Unaccounted for Losses in Boiler Tests.

Friday morning will have papers on Selection of Steam Generating Equipment by F. H. Rosencrants, on

Future Boiler Plants by Geo. A. Orrok, on Mid West Coals and Stoker Performance by E. L. McDonald.

In the afternoon H. N. Dunbar will speak on The Fly Ash Problem and Col. E. H. Whitlock will head a discussion on Air Pollution Problems.

Thursday evening, a joint banquet will be held at which the principal speaker will be A. O. Caldwell, Editor of Electronics.

Since notable engineers have signified their intention of being present, as a means of keeping abreast of the times, of being informed of late developments in the power field and of exchanging ideas with men experienced in many endeavors, a real opportunity is afforded.

Sessions of the Midwest Power Conference and the Fuels Meetings will be held in the Stevens Hotel on Michigan Blvd.

C. C. Whittier
Vice-President,
Midwest Power Conf.

W. M. White
Vice-President,
Midwest Power Conf.

A. C. Willard
Vice-President,
Midwest Power Conf.

Paul Doty
Vice-President,
Midwest Power Conf.

Engineering and Power Exhibits

Midwest Engineering and Power Exposition will be in the Coliseum on Wabash Ave. near 16th St. Arrangement of booths will be as shown in the floor plans herewith. The Coliseum is divided into north, main and south halls. All numbers from 400 to 462 are in the north hall; Nos. 1 to 234 are in the main hall and Nos. 300 to 342 in the south hall.

In planning to visit the Show, memoranda should be made, from the Directory of Exhibits which follows, of features in which the visitor is specially interested and information desired. By entering these memoranda in a pocket notebook to be taken to the show, time will be saved and overlooking of opportunity forestalled. Every exhibit will be worthy of attention but one's special interests will be given first place in getting data for future reference.

Making the acquaintance of other engineers and experts in the booths should by no means be neglected. Such contact and the knowledge of where to turn for assistance in solving puzzling problems are worth the time, effort and slight expense incurred in a visit to Chicago during Power Week, Feb. 10 to 14.

Power Plant Engineering will be in booth 54 ready to serve its friends in every way possible. This will be headquarters for appointments, for getting any desired information and for rest and visiting.

The directory following gives the names of exhibitors, location in booths, the most notable features of the exhibits and the names of representatives who will be on hand to meet and serve you.

Directory of Exhibits

Ahlberg Bearing Co., Booth 13
317 E. 29th St., Chicago, Ill.

Complete line of single and double row annular C. J. B. ball bearings will be shown; also Ahlberg ground bearings to replace worn bearings, available to all industrial plants. C. J. B. and Hoffmann Self-Aligning ball bearings, industrial line shaft and pillow blocks for heavy and light duty will be included.

Representatives: C. J. Bender, president; F. O. Burkholder, vice president and sales manager; G. L. McGregor, assistant sales manager; R. H. Kelly, B. B. Clark, district sales managers; C. W. Pearsall, Chicago branch manager; B. J. Baker, W. H. Fettkether, J. K. Weiser, M. G. McGregor.

Alexander Brothers, Booth 65
14 South St. Philadelphia, Pa.

Tentacular transmission belting, operating on short center drives, will be shown and demonstrated in this exhibit.

Representative: J. L. de Rabot, consulting engineer in charge.

Allen-Sherman-Hoff Co., Booth 98
225 S. 15th St., Philadelphia, Pa.

Here will be found a Hydroseal Ash Pump, a Hydrovactor and a Wind Swept valve on display, all three products being cut away to show clearly the method of operation. The Hydroseal pump is used with the Hydrojet System of ash removal for conveying ash-laden water considerable distances to fill in lowlands or to elevate refuse to an overhead storage bin. The Hydrovactor and Wind Swept valve are principal units of the Hydrovac System of soot, dust and fine materials handling, removing soot from the hoppers by vacuum through the Wind Swept valve, thoroughly mixing it with water in the Hydrovactor and then discharging it to point of disposal.

Allis-Chalmers Mfg. Co., Booths 104-6
Milwaukee, Wis.

American Air Filter Co., Inc.,
20 N. Wacker Drive, Chicago. Booth 435

American Arch Co., Inc., Booth 74
60 E. 42nd St., New York, N. Y.

Products to be shown will be sectionally-supported, air-cooled furnace walls and suspended arches.

Representatives: G. S. Carrick, general manager industrial department; F. D. Hazen, Pittsburgh manager.

American Brass Co., Booths 412-13
Waterbury, Conn.

Admiralty and Ambrac condenser tubes, condenser head plates, Everdur metal, Anaconda welding rods, Anaconda brass pipe, copper tubes for use with compression fittings, extruded shapes, die-pressed parts, rods, bars and segments, and Anaconda sheet metal will be exhibited. Of special interest will be the exhibit of Everdur metal, a copper-silicon-manganese alloy which combines the strength of steel with greater resistance to corrosion than copper and which is

being widely used for bolts, nuts, washers, screws, marine and electrical hardware and castings. Considerable interest is being shown in Everdur as a tank metal since it can be welded as readily, and in the same manner, as steel.

Representative: W. Harold Dowd in charge.

American Metal Hcse Co., Booth 432
Waterbury, Conn.

This display will include a complete line of flexible metallic hose and tubing together with fittings for them, for the conveyance of practically all types of fluids and gases. Sections will show the interlocked construction and thickness of metal walls.

Representatives: Alex B. Friedman, Chicago agent; W. J. Loughman, H. C. Garness, Everett B. Merriman.

American Soc. Mech. Engrs., Booths 94-5
29 W. 39th St., New York, N. Y.

Anaconda Copper Mining Co., Booth 412
25 Broadway, New York, N. Y.

Appleton Car Mover Co., Booth 228
Appleton, Wis.

Appleton Electric Co., Booth 158
1701 Wellington Ave., Chicago, Ill.

Here will be found a complete line of threaded and no-thread malleable Unilets for rigid conduit, as well as a complete line of malleable Unilets, couplings and connectors for thin wall conduit; also a line of Take-up reels for ordinary lighting as well as for transmitting current to motors for all kinds of movable machinery. Particular emphasis will be placed on a line of cast malleable Vaporproof fittings and Explosion-proof fuse switches.

Representatives: A. S. Merrill, general sales manager; E. G. K. Anderson, chief engineer; E. A. Hakanson, J. T. McHenry, A. F. Hakanson.

Armstrong Machine Works, Booth 404
Three Rivers, Mich.

Here will be found a complete line of steam traps as well as a glass model operating on steam whereby the operation cycle and advantage of the Armstrong construction may be observed.

Representatives: T. H. Rea, sales manager; O. E. Ulrich, factory representative.

Atwood & Morrill Co., Booth 137
Salem, Mass.

Bleeder valves of the oil closing type, special relief valves, condensate traps, and one or two special pieces of auxiliary equipment will be shown.

Representative: C. P. Atwood.

Auburn Stoker Corp., Booths 194-5
Auburn, Ind.

Here will be upon exhibition the regular line of Auburn Hydraulic underfeed stokers, also a smaller type of stoker of similar design, constructed to meet the needs of the smaller commercial and manufacturing buildings. Various cut-out models to show construction of automatic coal control and of the rotary gear pump which is not only an outstanding part of the Auburn stoker but will be of interest to manufacturers who need a pump with sufficient pressure and power to operate stokers, oil burners, booster tanks and the like.

Representatives: B. O. Fink, president; T. G. Hereford, sales manager; H. H. Fitch, chief engineer; C. E. Schrage, Chicago office manager, and H. E. Nelson, Chicago sales engineer.

E. B. Badger & Sons Co., Booths 217-18
Boston, Mass.

Complete line of Badger expansion joints will be shown.

Representatives: H. W. Coombs, sales manager; F. R. Heath, A. R. Lawrence.

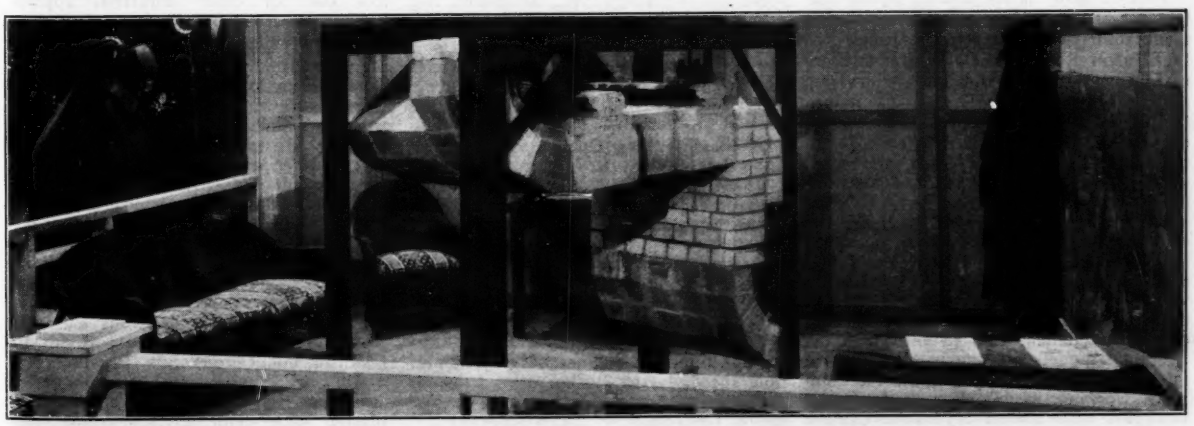
Bailey Meter Co., Booths 159-61
1050 Ivanhoe Rd., Cleveland, Ohio.

Following Bailey products will be shown: Boiler Meters and multi-pointer gages for use in guiding combustion and boiler operation. Meter automatic control as applied to the operation of steam boilers and to the maintenance of various factors in process work. Fluid meters, both mechanically and electrically operated, for the measurement of steam, water, gas and other fluids. Thermo-hydraulic feedwater regulators, pump governors, excess pressure regulators and control valves. Selsyn-operated devices for the remote indication and record of pressure, draft, liquid level, motion, speed and other factors. Copper tubing and Dieform fittings for the connection of lines on fluid meters, draft gages and the like. Among the special features of the exhibit will be a Bailey control drive cut away to show the operation of solenoid-operated clutches, time limits, travel limits and other distinctive features; also a large display of photographs, diagrammatic layouts and chart records from actual installations of Bailey meter control at various industrial plants and central stations throughout the country. Some of the most recent products will be Selsyn-operated devices for long distance transmission of numerous factors. The most interesting of these, a power type Selsyn pressure transmitter, will operate a 36-in., double-face internally illuminated Selsyn indicator, of rugged construction, simple design, extreme accuracy and reliability in operation.

Representatives: H. M. Hammond, manager of sales and engineering, in charge.

Barber Colman Co., Booth 407
Rockford, Ill.

An operating exhibit will show a line of motor-operated steam radiator and steam line valves and damper controllers. This equipment is powered by a small shading-ring induction motor with squirrel cage rotor, for low voltage operation



and extremely powerful, controlled by various types of thermostats. The equipment is arranged for application to almost any type of heating and ventilating system. Details of the electric system of temperature control will also be shown.

Representatives: R. P. Dewey, C. J. Braatz, T. K. Greenlee, D. J. Stewart, Jos. Zwolanek, Rockford; C. F. Hayden, L. C. Plaehn, Chicago office.

Barco Manufacturing Co., Booths 112, 113
1801 Winnemac Ave., Chicago, Ill.

Products shown here will include Barco flexible joints, swivel joints and lubricated plug valves in various sizes.

Representatives: J. T. Ross, in charge; C. O. Jenista.

regulator and fan engine control will be shown. A Mason Hydraulic regulator connected up with a balanced valve will be operated under air pressure and in addition a bank of various kinds of regulating valves equipped to give actual working demonstration of maintaining steady delivery pressures under varying conditions.

Representatives: Harry Barrett, James G. Christie, Clifford M. White, Harley B. Westphal, S. O. Olsen, Marcus A. Hallberg, Wilbur J. Sprenkle; William B. Gearon and F. Kenneth Morrison of Mason Regulator Co.; Mr. Hellmer, Mr. Priser, H. B. Fridstein of Instant Water Heater Co.; O. E. Ulrich, A. M. Armstrong, T. H. Rea, A. L. Jones of Armstrong Machine Works.

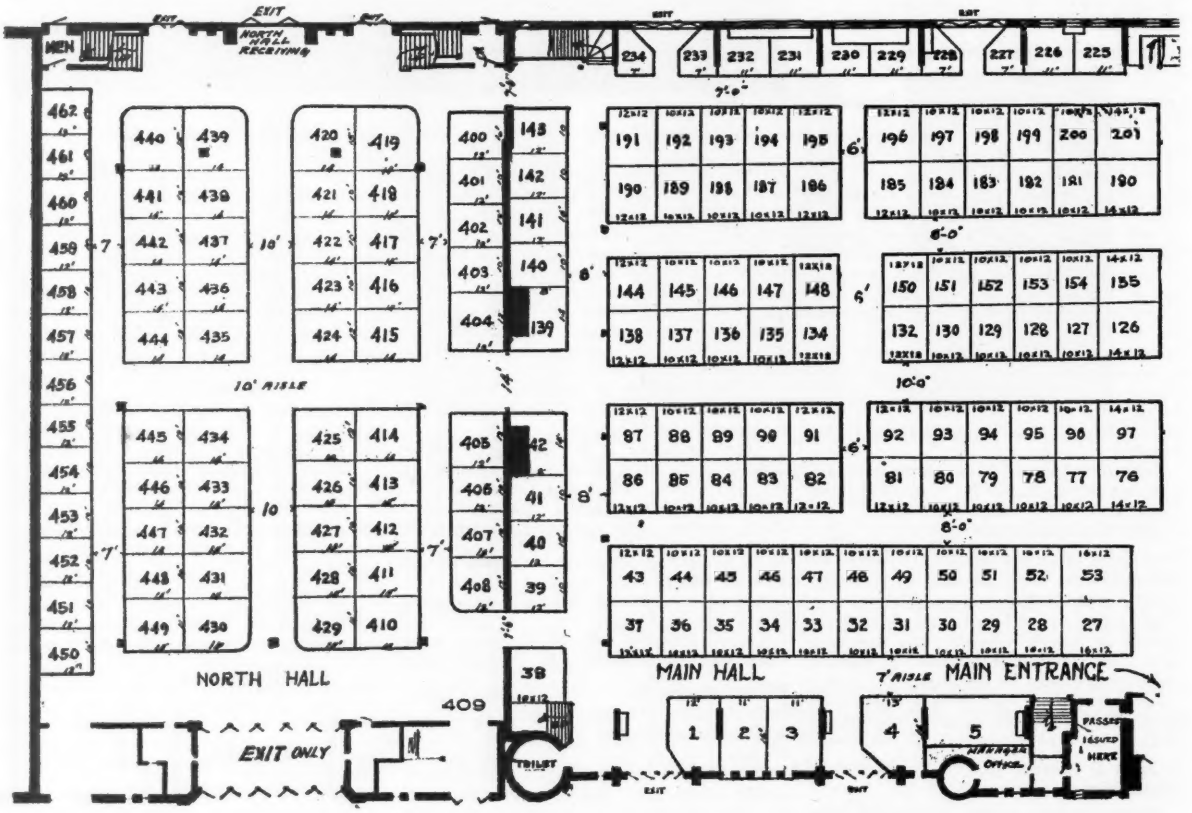
Black & Decker Mfg. Co.,
Towson, Md. Booths 320-21, 340

This company will display, in conjunction with the Barrett-Christie Co., H. Channon Co. and the Great Lakes Supply Co., a representative line of Black & Becker-Van Dorn tool grinders, together with its new variable speed, independent spindle buffer. Also will be shown high-cycle tools, large foundry grinders and Universal portable electric tools.

Representatives: A. M. York, Chicago branch manager; G. J. Coffey, in charge; E. W. Ristau, W. H. Wohlen.

Bodine Electric Co., Booth 187
2254 W. Ohio St., Chicago, Ill.

Standard fractional horsepower motors



Barrett-Christie Co., Booths 402-4
108 N. Clinton St., Chicago, Ill.

This company is the district representative for the Armstrong Machine Works, manufacturers of Armstrong traps; for the Mason Regulator Co., manufacturers of Mason regulators and balanced valves; for the Instant Water Heater Co., manufacturers of Instant steam water heaters. Working model of Armstrong steam trap, made entirely of glass, connected up to a glass pipe coil, will operate under actual steam pressure generated by an electric boiler so that draining the coil together with what takes place inside the trap will be under observation at all times. A most interesting feature will be the visible demonstration of how the trap handles air and also the effect of air on condensation in the pipe coil. Sectional models of various Mason regulators and balanced valves, also a complete working model of a boiler room equipped with Mason Hydraulic damper

Bartlett Hayward Co., Booth 22
Scott and McHenry Sts., Baltimore, Md.

Fast's Self-Aligning coupling will constitute the exhibit.

Representatives: M. T. Maguire, E. G. Johnson.

Bayer Company, Booth 196
1504 S. Grand Blvd., St. Louis, Mo.

Biax Flexible Shaft Co., Booth 341
Long Island City, N. Y.

This display will consist of flexible shaft power tools including: 2½-hp. high-speed rail grinder; ½-hp. hand shear; automatic screw driver and nut setter; auto body sanding and polishing machine with right angle attachment; variable-speed die sinking equipment; rotary, reciprocal and high speed attachments; wide assortment of rotary files; heavy duty grinding, sanding and buffing machines, single and multiple speed, 1/10 to 2½-hp.

Representatives: H. T. Stroh, R. Wezel, J. Levison.

with and without gear reductions will be shown, but particular emphasis will be laid upon special motors for power control and for other industrial applications.

Representatives: H. D'Almaine, C. E. Walters, F. W. Yarline, W. M. Yogerst.

Boston Gear Works Sales Co.,
North Quincy, Mass. Booths 415-17

Here will be exhibited representative types of Boston Gear stock products of every description, consisting of gears, speed reducers, Renold-Boston and Duckworth-Boston inverted tooth and roller chain drives, Doehler-Boston die-cast stock gears, Curtis universal joints, "Nice" ball bearings, light transmission parts.

Representative: Jas. A. Stephen, Chicago district sales manager.

Botfield Refractories Co., Booth 100
Swanson and Clymer Sts., Phila, Pa.

All refractories products, including Adamant fire brick cement, Adachrome plastic super-cement, Adachrome fines

and aggregate, Adapatch and the Adamant gun, will be exhibited.

Representatives: A. H. Engstrom, sales manager in charge; W. B. Smith, midwestern field representative.

Breuer Electric Mfg. Co., Booth 452
852 Blackhawk St., Chicago, Ill.

Products to be exhibited will include: Tornado portable electric blowers; industrial vacuum cleaners and portable electric paint sprayers; Nobetur spring winders; Tornado heat blowers.

Representatives: A. A. Breuer, general manager; D. E. Campbell, automotive division; R. H. Frish, blower division; D. H. Lynch, district representative.

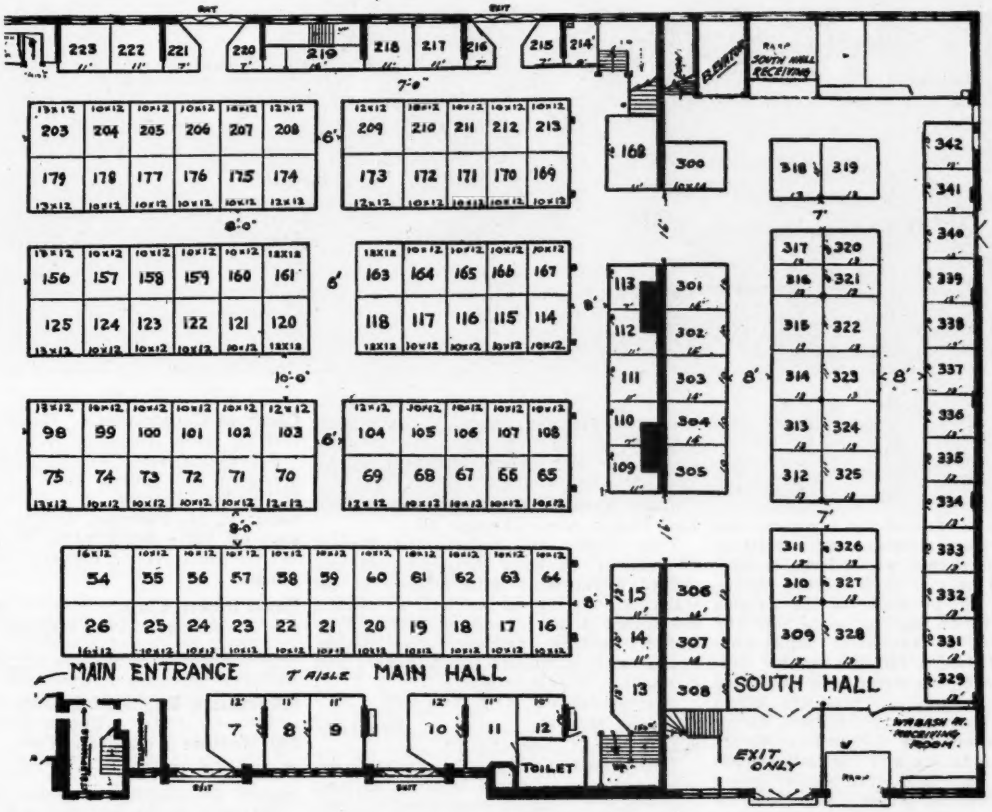
Brown Instrument Co., Booths 16, 17
Philadelphia, Pa.

Special display will consist of a Brown Electric flow meter manometer and indicating and recording instruments measuring flow through a pipe circuit, part of which is made of glass, so that the observer can see the flow through the orifice. The orifice plate itself is made of glass and the action of entrained air bubbles on either side of the orifice, as the column of liquid rushes through shows the conditions which produce the differential pressures on which the operation of the flow meter depends. A U-tube will be set up and connected across the orifice to show this pressure differential and means provided for varying the flow so that the relations between flow and differential pressure can be readily demonstrated. Another element of this display will be a sectional view of a Brown flow meter manometer, showing its changeable range tube and working parts. This display will occupy the central panel of a modern instrument board containing four other sections, respectively featuring Brown thermometers for power plant temperature records; pyrometers for stack and furnace temperatures; flow meters for steam, water, air oil and gas; recording gages for pressure, liquid level, CO_2 and other miscellaneous operating factors in power plant efficiency. Thermometers will be both resistance and pressure type. Pyrometers will be indicating and recording, also a special type for indicating and comparing Diesel engine cylinder exhaust temperatures. Flow meters will be the indicating model and the circuit chart recorder, also strip chart recording of single record and duplex types.

Representatives: George W. Keller, vice-president and general sales manager; C. L. Saunders, Chicago district manager; W. L. Gustafson, I. K. Farley, M. S. Jacobs, E. M. Robinson, P. E. Bjork, W. H. Sisson, Chicago office.

Buffalo Forge Co., Booths 120-22
Buffalo, N. Y.

This exhibit will consist of one of the heavy-duty, induced draft fan rotors, shaft, water-cooled bearings and pedestals which the company is furnishing for the New Waukegan Station of the Public Service Co. of Northern Illinois, for Unit No. 5. These are some of the largest fans built up to the present time for powdered coal induced draft fan service. Each fan is arranged for double motor drive, the largest motor being 900 hp.



The Bristol Co., Booth 39
Waterbury, Conn.

This exhibit will include instruments for recording, indicating and automatic control. Some of the important new developments include: compact rectangular case for round chart recording electrical instruments; flush type round and strip chart recorder cases including pressure and vacuum gages, thermometers and pyrometers; moisture-proof recording thermometer with sensitive external bulb for atmospheric temperatures; combination indicating pyrometer and rotary switch; thermometer controllers for low and medium temperatures; moisture-proof indicating pyrometer case; indicating dial-type gages and thermometers; air-operated pressure, draft and temperature control; various fixtures for thermo-couples and sensitive thermometer bulbs and fittings; industrial type mercurial thermometers.

The shaft is 16½ in. diameter. The rotor has novel features in the way of wearing strips for protection against erosion from the powdered coal ash.

Representatives: O. S. Ryan, in charge; C. C. Cheyney.

Bull, E. H., Booth 196
319 S. Michigan Ave., Chicago, Ill.

Burnham & Lindsey, Inc., Booths 169-70
565 W. Washington St., Chicago, Ill.

Cactizona Products Co. of Chicago,
230 W. 63rd St., Chicago, Ill. Booth 213

Andrew C. Campbell, Inc., Booth 445
Bridgeport, Conn.

This exhibit will show the Campbell Nibbling machine and the newest Abrasive cut-off machine.

Representatives: A. A. Hall, H. R. Powell, Joseph Johnson.

The Carborundum Co., Booths 85-6
Perth Amboy, N. J.

Actual reproductions of sections of boiler furnace walls showing Carbofrax

utilized in conjunction with water and air-cooled wall construction will be exhibited; also various shapes of Carbofrax-Carborundum brand silicon carbide and Aloxite brand electrically fused aluminum oxide materials.

Representatives: R. A. Beverly, district sales manager; R. J. Penny, R. S. Baker, A. I. Jacobs, sales engineers.

Carter Bloxonend Flooring Co., Booth 58
902 Walnut St., Kansas City, Mo.

Product on display will be Bloxonend flooring for trucking areas in industrial plants. The exhibit will consist of photographs of representative installations and a panel made up of standard 8-ft. lengths of flooring.

In this exhibit will be found steam purifiers, line separators for steam, gases, vapor and compressed air, evaporator units and other similar equipment.

Representatives: D. L. Darnell, sales manager; Messrs. Burnham, Simpson and Branston, Chicago; Angus Leitch, South Bend; Fred R. Liggett, Chicago railway sales office.

Chaplin-Fulton Mfg. Co., Booth 62
23 Penn Ave., Pittsburgh, Pa.

Chicago Fuel Saver Co., Booth 221
5510 Broadway, Chicago, Ill.

This exhibit will show several different sizes and types of Field Barometric draft controls and fuel savers.

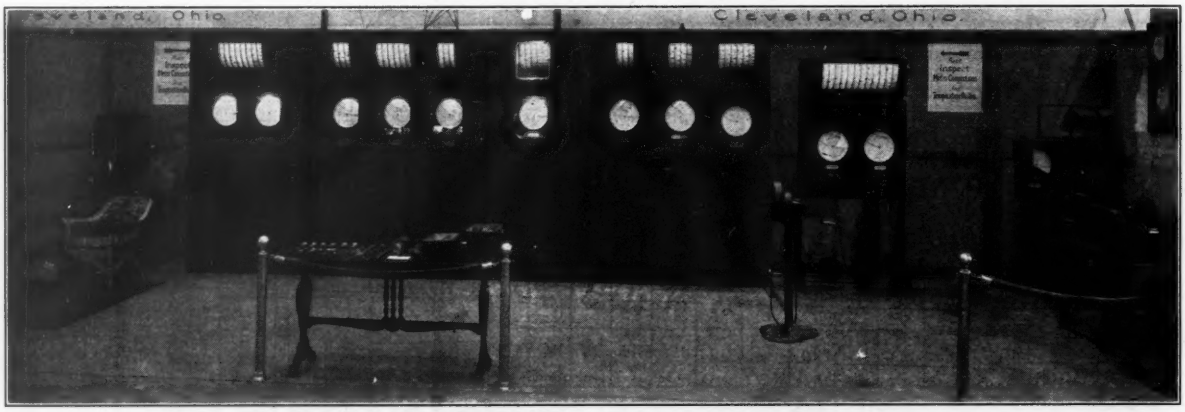
Here will be shown a machine driven by a system of belts, the function of which is to show the difference in efficiency between belts treated with Cling-Surface belt preservative under no tension and belts of the same make and size untreated and running under high tension.

Representative: Gordon N. Parker, vice-president, in charge.

Clipper Belt Lacer Co., Booth 436
Grand Rapids, Mich.

Here will be found the entire Clipper line consisting of various models of belt lacers, belt hooks, belt cutters with safety feature and clipper connecting pins.

Representative: G. E. Farmer, factory representative, in charge.



Representatives: John Thomasma, manager, Chicago office; J. G. Galvin, advertising manager.

A. W. Cash Co., Booth 168
Decatur, Ill.

Aluminum models of the complete line of Cash standard reducing and regulating valves will be shown, with a large number of types and sizes of stock valves. Working exhibit will be made of the various regulators which go to make up the Craig system of automatic combustion control, including a full size master controller and draft regulator with accessory equipment. Among the products shown will be regulators for fans, stokers, dampers, gas burners and oil burners; valves in pressure-reducing and regulating types for air, oil, hot and cold water, steam and gas; valves for pressure relief and for vacuum relief, also for ammonia expansion and control; strainers, pump governors and other steam specialties.

Representatives: H. H. Shugart, vice-president and general manager; C. M. Terry, chief engineer; C. C. Fremon, sales engineer valve division; C. W. Court, manager combustion control division; W. R. Reitz of Reitz Sales Co., Chicago representatives for valves; J. F. Meyer, Meyer-Ekstrom Co., Chicago representatives for combustion control.

Celite Products Co., Booth 172
1320 S. Hope St., Los Angeles, Calif.

Central Valve Mfg. Co., Booth 42
231 E. 95th St., Chicago, Ill.

Brass and iron gate valves will be shown in all styles for pressures of 150 to 300 lb. Featured will be the Kelly Neway gate valve of different design in sizes from 2-in. to 12-in.

Representatives: C. S. Pope, vice-president; P. J. Kelly, C. F. Pigott.

Centrifix Corporation, Booth 170
3029 Prospect Ave., Cleveland, Ohio.

Representatives: W. J. O'Neil, president; F. M. Downes, secretary-treasurer; F. W. Bentley, sales engineer; P. C. Weicker, chief engineer.

Chicago Rawhide Mfg. Co., Booth 326
1267 Elston Ave., Chicago, Ill.

This display will include the Perfect oil retainer, showing three adopted and proved applications with method of installation, sealing oil as well as water; also other articles such as special type leather packing, rawhide and bakelite gears, rawhide mallets and hammers and mechanical leather products.

Representative: R. J. Vedovell.

Clements Mfg. Co., Booth 317
601 Fulton St., Chicago, Ill.

This company will display its latest developments of industrial blowing, suction, cleaning and spraying equipment, of portable type to operate from any electric light socket. An outstanding feature will be a display board of all the parts entering into the construction of the Clements Cadillac blower. In addition to the blower, the Clements Cadillac auto cleaner will be shown.

Representatives: W. J. Clements, vice-president; J. J. Downs, sales manager; C. A. Bremmer, manager blower division; G. A. MacLean.

The Cleveland Worm & Gear Co., Booth 57
3249 E. 80th St., Cleveland, Ohio.

This exhibit will include standardized worm gear reduction units and high-efficiency worm gearing for industrial and automotive service.

Representatives: Howard Dingle, president; R. E. Dittoe, assistant secretary; F. E. Bardrof, sales manager; John D. Kinsey, Chicago district manager; Ralph R. Day.

Cling-Surface Co., Booth 141
1032 Niagara St., Buffalo, N. Y.

Cochrane Corporation, Booths 174, 175
17th St. below Allegheny Ave., Phila., Pa.

Representatives: H. E. Sibson, vice-president and general sales manager; J. D. Yoder, director of softener department; F. M. Paterson, director of boiler blow-off valve department; H. J. Meier, W. S. Elder, G. J. Kipper, Chicago, in charge.

Cokal Stoker Corp., Booth 304
400 N. Michigan Ave., Chicago, Ill.

Combustioneer, Inc., Booths 225-7
1829 S. 55th Ave., Chicago, Ill.

Combustion Engineering Corp., Booths 27-28, 52, 53
200 Madison Ave., New York, N. Y.

Connery & Co., Booths 156-7
Second St. above Erie Ave., Phila., Pa.

Products to be featured will be Connery's Improved Expansion Stiffener as applied to breechings and air ducts, improved air cooled damper, improved expansion stack connection and application of guide vanes in duct work.

Representatives: W. M. Connery, A. D. Stewart, D. H. Skeen.

Consolidated Ashcroft-Hancock Co., Inc., Booths 63-4
100 E. 42nd St., New York, N. Y.

Cook Electric Co., Booth 433
2700 Southport St., Chicago, Ill.

Products displayed will include: metal bellows for air, oil, steam, water and acids; automatic valves for steam, hot water, gas; automatic temperature regulators for levers, dampers, shutters; electric vapor motor, a device that develops great power with small current consumption and the timing, length of travel and pressure developed can be accurately controlled within a wide range; anti-syphon valves, oil tank gages and automatic fuel oil pumps.

Representatives: G. R. Folds, president; J. S. Baker, engineer; J. F. Jaap, E. Rogge, A. M. Wilkins, E. D. Swanberg.

Coppus Engineering Corp., Booth 61
Aeroplane heat killer and Cable manhole ventilator will be exhibited and demonstrated.
Representatives: H. Himelblau; T. Agazim.

Crane Company, Booths 203-4
836 S. Michigan Ave., Chicago, Ill.

Croll-Reynolds Engineering Co., Inc.,
17 John St., New York, N. Y. Booth 146
Principal in this exhibit will be Flexo-Disc expansion joints, with samples of each of the standard joints for high and low pressure and for welded pipe lines in single and duplex form; also samples of the flexible element welds and other parts. In addition will be displayed photographs of heat transfer equipment such as heaters, exchangers, condensers and evaporators.
Representatives: Robert S. Croll, Ernest E. Lee.

Crosby Steam Gage & Valve Co.,
30 Church St., New York, N. Y. Booth 123
In this booth will be a five-panel ebony asbestos gage board, having mounted thereon fifteen 8½-in. flush-mounted gages for various services, both indicating and recording type. Also an all-steel-movement gage with forged steel socket and tip, steel tube, forged steel movement with case hardened sector and pinion. Safety and relief valves with one 1500-lb. safety valve in section and one relief valve with packed lifting lever which makes the valve bottle tight on the discharge side, will be exhibited, also a fluid pressure scale for testing gages.
Representatives: Carl F. Woods, president; George F. Felker, vice-president and sales manager; Frank H. Beror, western manager; John N. Irmen.

Dampney Co. of America, Booth 459
Hyde Park, Boston, Mass.

Davis Regulator Co., Booth 82
2541 S. Washtenaw Ave., Chicago, Ill.
Pressure reducing valves for steam air and water, exhaust relief valves for both non-condensing and condensing systems, non-return valves for turbine bleeder lines, noiseless check valves for steam, air and water lines, solenoid-operated valves and emergency stop valves will be shown.
Representatives: George C. Davis, president; J. C. Kinsley, Harvey R. Willard.

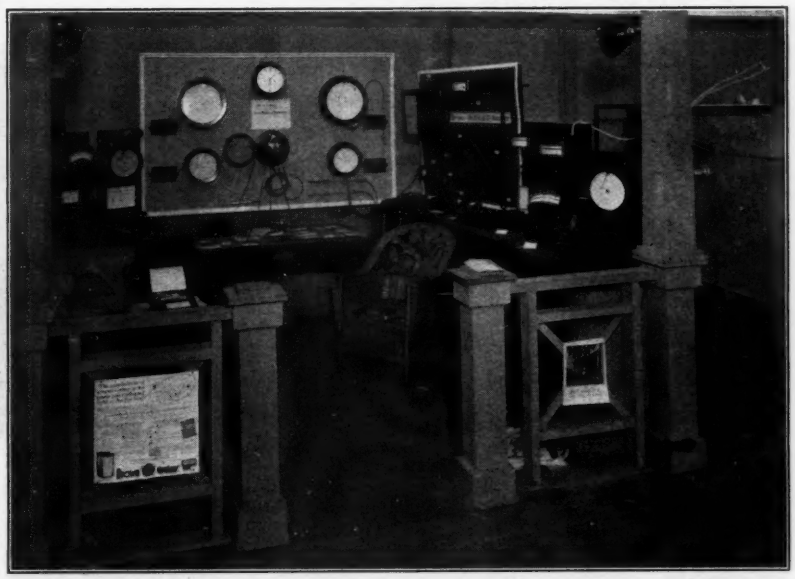
Dearborn Chemical Co., Booth 80
310 S. Michigan Ave., Chicago, Ill.
This company will exhibit along with literature, Dearborn feed water treatment, Domestic hot-water treatment, Seal Kote (boiler wall coating), lubricating oils, NO-OX-ID rust preventive, and cleaning powders.
Representatives: E. M. Converse; J. W. Harkins, city sales manager; M. M. Kutzer, H. M. Harrison, A. C. Herrmann.

Julian d'Este Co., Booth 21
6 Spice St., Boston, Mass.
Curtis engineering specialties here shown will include stock and sectioned models of pressure reducing valves for steam, water, air and gas; combustion and damper regulators; steam drainage traps of the float and open bucket types for separating service and return traps for lifting and boiler feed requirements; also tank and float valves for water level controls.

Representatives: D. A. Herrick, Boston; T. A. Touchton, United Steam Specialty Co., Chicago.

Delta Stoker Co., Booth 231-32
North Chicago, Ill.
Delta Hydraulic underfeed stoker will be exhibited together with its various parts separately.
Representatives: A. O. Dady, president, in charge; Edward Traub, division manager.

A. P. deSanno & Son, Booth 334
1615 McKean St., Philadelphia, Pa.
This company will exhibit its Radiac cut-off machine and grinding wheels, for cutting tubing, bar, round or flat stock of soft iron, nickel or high speed steel, monel metal and other materials.
Representatives: B. G. Hardy, J. C. Rinehart, S. M. Hershey, F. B. Soulas.



M. H. Detrick Co., Booths 182, 183
140 S. Dearborn St., Chicago, Ill.
Exhibit will be made of models and cuts of various design arches used in connection with stokers, boilers, oil stills and metallurgical furnaces; also Detrick sectionalized walls, both air cooled and insulated, used in connection with powdered coal, oil and gas fired boilers, stills, stokers and for backing up water cooled furnaces.
Representatives: R. C. Warner, J. S. Roman, Tom Vaughan, Otto Jaros.

Diamond Power Specialty Corp.,
Detroit, Mich. Booths 178, 179
This exhibit will consist of Diamond high-pressure "loose window" flat glass gages and water columns. Full size apparatus cuts are to show working parts and a glass and column in operation will be displayed. Also the latest developments in soot blower apparatus will be shown.
Representatives: W. P. Thomas, secretary; George L. Davis, assistant sales manager; E. K. Uebe; C. L. Conrad; M. J. Miller; C. D. Rich; S. W. Calkins.

Dings Magnetic Separator Co., Booth 199
650 Smith St., Milwaukee, Wis.

Douglass Brothers Co., Booths 446-7
352 Whiting St., Chicago, Ill.

Drake Non-Clinkering Furnace Block Co., Inc., Booths 136-7
5 Beekman St., New York, N. Y.
This exhibit will be a part of the general exhibit of the Ernest E. Lee Co. and will include principally water wall tubes. Because the trend in water cooling is to an all-metal surface including bare tubes with protective armor for protection only, various combinations will be shown: Carborundum protective armor with finn blocks on the rear of the tubes; Thermofit protective armor with finn blocks on the rear of the tubes; BTU Armor-clad construction as protective armor on the front and on the back of the tubes to present an all-metal surface between the tubes. The Finn block will be exhibited for the first time, a bolted-on construction to provide an all metal exposure between bare tubes. BTU Suspended air-cooled wall both in fire clay and with a silicon carbide veneered face, also standard BTU Drake blocks and the BTU Improved combustion system will be shown. Feature will be a new line of BTU cements and other products.
Representatives: Ernest B. Priebe, president and treasurer; S. M. Finn, general manager; B. J. Schneider, Indianapolis; B. E. Eickmeyer, St. Louis; H. R. N. Johnson, Minneapolis.

C. A. Dunham Co., Booths 71-3
450 E. Ohio St., Chicago, Ill.

Durametallic Corp., Booth 410
Kalamazoo, Mich.

Economy Pumping Mach. Co., Booth 165
3431 W. 48th Place, Chicago, Ill.
The Economy exhibit will contain a water supply, drainage, boiler feeding and complete set of pumping equipment for water supply, drainage, boiler feeding and pumps for municipal sewage pumping stations. Probably the most interesting part of the exhibit will be a high-efficiency clear water pump for boiler feeding and general service which will be in operation discharging water at 170 lb. pressure. Items shown will include: double suction horizontally split case centrifugal pumps, 8-in. of 3500 g.p.m. at 200 ft., 4-in. of 550 g.p.m. at 100 ft., 1½-

in. of 150 g.p.m. at 200 ft., 2½-in. multi-stage of 175 g.p.m. at 600 ft.; 1¼-in. vertically split case multi-stage of 20 g.p.m. at 400 ft. in operation; 4-in. vertical open shaft ball-bearing, non-clogging pump of 500 g.p.m. at 25 ft., designed to pass 2⅝-in. spheres without clogging; 1½-in. vertical sump pump of 40 g.p.m. at 25 ft.

Representatives: R. H. Thomas, president; L. G. L. Thomas, vice-president; W. W. Huggins, secretary; H. R. Ryan, sales manager; W. D. Kane, F. W. Jackson.

Ehret Magnesia Manufacturing Co., Booth 90
Valley Forge, Pa.

Samples of Ehret's 85 per cent magnesia products, high temperature insulations and other insulating material in sectional and block forms will be found in this exhibit. Varying combinations to meet different conditions will be shown and the effectiveness of the installation demonstrated.

Representatives: H. G. Hill, technical engineer; Lawrence L. Shailer, Chicago branch manager, in charge.

Elgin Softener Corp., Booth 88
Elgin, Ill.

This display will consist of a small boiler electrically operated and equipped with the Elgin system of deconcentration to display the circulations that occur from a boiler to the deconcentrator equipment, also the sediment that collects in the deconcentrator. The deconcentrator and connecting lines will be of glass which will permit visitors to see what occurs when boilers are equipped with deconcentrators. In addition will be a demonstration of the Elgin Continuous blow-down system with heat exchanger and a further exhibit showing the Elgin Zeolite water softener.

Representatives: M. W. Lauer, J. M. Stewart, E. W. Scarritt, D. E. Lowman, C. L. Scribner.

The Fafnir Bearing Co., Booths 66-7
New Britain, Conn.

Complete line of ball bearings and ball-bearing power transmission equipment will be exhibited with particular emphasis on the heavy duty, maximum capacity ball-bearing design. Hanger boxes, pillow blocks, blower boxes, fan boxes, loose pulley applications will be included.

Representative: G. F. Stanley, manager industrial sales, in charge.

Filtrators Co., Booths 196-7
96 Liberty St., New York, N. Y.

Here will be found water-cooled Filtrator Type UW-3, complete with accessories, to provide non-chemical treatment of boiler water, for prevention of scale, pitting and corrosion. It employs a true colloidal solution for the treatment of any water irrespective of its chemical composition.

Representative: E. H. Bull, Chicago.

Fisher Equipment Co., Booth 228
508 S. Dearborn St., Chicago, Ill.

The Safety truck brake, a device for use on the ordinary two-wheel hand truck to provide safety to the trucker and high truck efficiency will be shown. Also the new Badger Steel shoe car mover and the Advance Safety car wrench.

Representative: Raymond D. Fisher, in charge.

The Fisher Governor Co., Inc., Booth 35
Marshalltown, Iowa.

This company will display the latest developments of pressure control specialties, gas pressure specialties and liquid level control devices. Of particular interest is the new type all ball-bearing stuffing box, a recent development of the Fisher laboratories which has been adopted as standard for all Fisher liquid level controllers and rotary bonnet lever valves. Also the Master Controller, Series 2200, an auxiliary pilot control unit, that uses as its operating medium air, water, gas or oil, will be displayed with a cross-sectional model. This control is for the application of close pressure regulation, dual control hook-ups and like conditions where severe operating conditions are encountered. The new Air-Block, pilot-operated liquid level controller unit, the new expansion tube pilot control for pressure regulators, with a full exhibit of the Fisher line, will complete the exhibit.

Representatives: L. W. Browne, president; P. A. Elfers.

Fitzgibbons Boiler Co., Booths 205-6
570 7th Ave., New York, N. Y.

Foley Manufacturing Co., Booth 319
11 N.E. Main St., Minneapolis, Minn.

On display will be Foley automatic saw filers, All-Purpose grinder, Electrakeen lawn mower sharpener and Automatic saw grinder. The main feature of the exhibit will be the actual filing of various saws, hand, band, and circular on the Automatic saw filer, also high-speed hack saw blades and metal cutting band saw.

Representatives: Wm. F. Rehbock, sales manager; G. L. Hudson, Jr., W. Johnson, Minneapolis; I. H. Stilwell, Chicago.

Foster Wheeler Corp., Booths 126-7
165 Broadway, New York, N. Y.

This exhibit will consist of a combination of full-sized sections of equipment and enlarged photographs of complete installations. The models will include sections of alloy-steel, radiant-heat superheaters; wing-wall type water-cooled furnace surfaces; type B armored, water-cooled furnace surfaces; heat exchanger; steam jet air pump, evaporator; sections of extended surface heating elements; expansion joints. Photographs and drawings will show some of the outstanding installations of the country and cover a variety of constructions, including those good for operating pressures of 1450 lb. per sq. in.

Representatives: T. H. Wilkins, middle west district manager, in charge; W. F. Meyer, O. E. Anderson, H. F. Eddy, K. H. Bedell, E. H. Chapin, P. R. Greenman, J. A. Farrell, D. W. Duvall, J. K. Seabright, A. N. Dietze, W. H. MacKay, E. R. Goodrich, F. G. Page.

The Foxboro Co., Booths 55, 56
Foxboro, Mass.

This company will exhibit a complete line of power plant instruments for indicating, recording and controlling temperature, pressure and flow. Of special interest will be the new high-pressure flow meter for working pressures up to 2500 lb. per sq. in. Also the newly developed Chrome Molybdenum alloy-steel helical and bourdon movements for recording and indicating gages, which were developed to meet the demand for uninterrupted service.

Representative: C. H. Roessner, manager Chicago office, in charge.

Fuller Lehigh Co., Booths 180-1, 200-1
Fullerton, Pa.

This space will be utilized to show the grinding elements of the new Fuller Lehigh Type B pulverizer, an air separation ball mill of spherical ball and grinding ring principle in which fineness is unaffected by wear of parts. Also will be exhibited two large illuminated shadow-boxes, in which will be mounted cross-sectional drawings of the new Fuller Lehigh pulverizers, the Type C and the Type B similar in design although of smaller capacity and utilizing a single row of grinding balls.

To show drawings and photographs of some 50 installations of pulverized-coal equipment and Bailey water-cooled furnace walls, a special displayor will be

used giving some interesting facts regarding each of these installations.

Representatives: E. J. Billings, vice-president; W. E. East, Chicago manager; R. A. Hawk, in charge.

The Garlock Packing Co., Booth 15
Palmyra, N. Y.

In the exhibit will be included a full line of mechanical packings featuring Garlock Chevron packing and Garlock Button Hole tape.

Representative: H. J. Ramshaw, Chicago district sales manager.

General Insulating & Mfg. Co.,
Alexandria, Ind. Booth 191

There will be displayed a complete line of Gimco Rock Wool insulating products for heat, cold and sound insulation. A new type of pipe covering to be known as Gimco "Savall" will be introduced, the outstanding features of which are low conductivity, absolutely tight seams and joints at all temperatures, lightness in weight, toughness and durability.

Representative: Orval White, sales engineer.

Graver Tank & Mfg. Corp., Booth 91
East Chicago, Ind.

Products to be shown will be a hot process softener and meter control device.

Representatives: J. G. Dye, J. J. Felsecker, A. C. Corrao.

Hannifin Mfg. Co., Booth 18
621 S. Kolmar Ave., Chicago, Ill.

Harbison-Walker Refractories Co.,
Booth 23
Farmers Bank Bldg., Pittsburgh, Pa.

Specimens of first and second quality fire-clay brick produced in various manufacturing districts will be displayed; also, high alumina brick which are coming into favor for power plant boiler settings. Also samples of Magnesite, Chrome Metalkase and Duro Acid-Proof brick, Thermolith and Firebond high-temperature cements and samples of raw materials from which the various types of refractories are made will be shown. The feature of the exhibit, however, will be the projection of a motion picture film of five reels, two reels showing the production of fireclay refractories, two reels covering the manufacture of silica, magnesite and chrome refractories and the fifth reel showing scenes in the control and research refractories.

Representatives: W. B. Coullie, general sales manager; J. Spotts McDowell, director of research; E. B. Guenther, advertising manager; H. L. Smalley, Chicago district sales manager; R. M. Sievers, St. Louis district sales manager; F. B. Cornell, Detroit district sales manager; R. E. Armstrong, Indianapolis district sales manager; J. H. Owen, T. F. Stockslager, R. E. Allen, E. O. Baierbach, H. T. Lewis.

Jos. Harrington Co., Booths 92-3
Harvey, Ill.

Arthur Harris & Co., Booth 220
210 N. Curtis St., Chicago, Ill.

This company will exhibit Harris floats of special construction and other copper specialties.

Representatives: Arthur J. Harris, George C. Harris, A. W. Baumann.

The Hays Corporation, Booth 313
Michigan City, Ind.

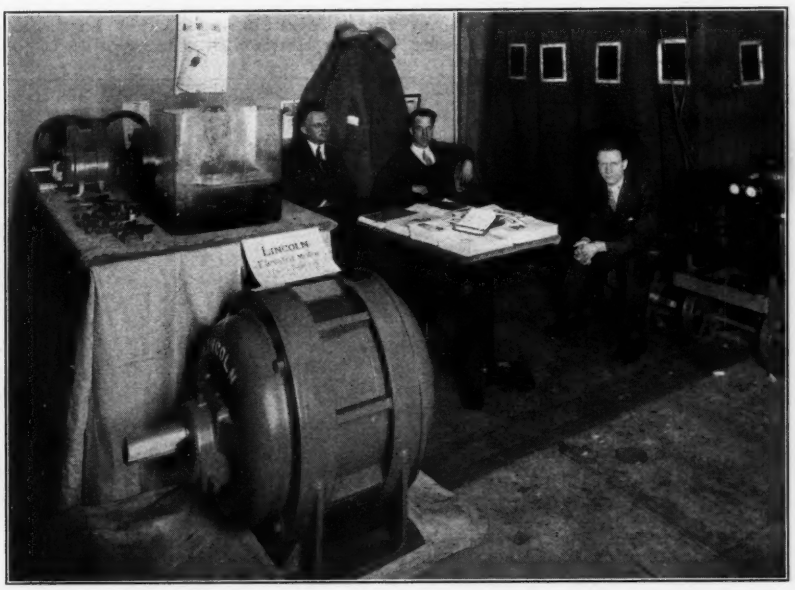
Products to be exhibited will be: Hays Portable combustion test sets, flue gas analyzers; automatic CO_2, draft and flue gas temperature recorders; Pointer Type, draft, pressure and differential gages; Automatic CO_2 indicator and a complete Hays boiler panel, including instruments.

Representatives: Phil T. Sprague, president; Shirl M. Rudolph, sales manager; J. W. Murphy, Chicago; George H. Fredericks, Milwaukee; J. T. Vollbrecht, St. Louis.

Heine Boiler Co., Booth 27
St. Louis, Mo.

Himelblau, Agazim & Co., Booth 61
30 N. Dearborn St., Chicago, Ill.

Companies exhibiting with this firm will include the following manufacturers of equipment: Tube-Turns, Inc., Chaplin-Fulton Mfg. Co., Coppus Engineering Corp., O. E. Frank Heater & Engr. Co., Joseph Kopperman & Sons, Korfund & Co., Lehnco Co., Webster Tallmadge Co., Henszey De-Concentrator Co.



Representatives: Harry Himelblau, T. Agazim.

Hoffman Combustion Engineering Co.,
410 Ford Bldg., Detroit, Mich. Booth 197

This company will exhibit the Firite automatic stoker.

Representatives: J. A. Hoffman, vice-president and chief engineer; Fred H. Dorner, Milwaukee; E. H. Bull, Chicago.

Illinois Engineering Co., Booths 405-6
Racine Ave. at 21st St., Chicago, Ill.

Complete line of radiator valves, radiator traps, blast traps and certain steam specialties will be shown in a brilliantly illuminated shadow box. A completely piped set-up of a vapor system so far as the boiler room equipment is concerned, showing boiler return trap and heat retainer in cut section, as they would appear in service, will be offered for inspection. Under actual steam working conditions will be exhibited a glass model of the Eclipse steam trap together with full size Blast traps draining a standard type unit heater operating under the Zone Control system. Featured will be a model showing three full size electrically-operated Zone Control valves for heating systems with their attendant panel board connected to available current, so that the operation of the panel board with its tell-tale lights and the operation of the valves themselves may be observed simultaneously.

Representatives: R. L. Gifford, president; James C. Matchett, vice-president; J. L. Ehretsman, A. F. Nesbet.

Illinois Malleable Iron Co., Booth 210
1801 Diversey Parkway, Chicago, Ill.

Illinois Stoker Co., Booths 134-5
Alton, Ill.

This company will have in its booth a newly developed stoker.

Representatives: J. P. Polster, Chicago; C. W. Warinner, Alton.

Illinois Testing Laboratories, Inc.,
Booth 303
141 W. Austin Ave., Chicago, Ill.

Here will be exhibited portable and stationary indicating pyrometers and other temperature measuring instruments for measuring flue gas, up-take and stack temperatures in steam power plants and exhaust temperature pyrometers for Diesel engines and other uses.

Representatives: J. A. Obermaier, M. D. Pugh, sales manager; C. L. Schmal.

Hitchcock Co., Booth 117
31 St. James St., Boston, Mass.

Independent Air Filter Co., Booth 461-A
29 S. Clinton St., Chicago, Ill.

Products exhibited will be two types of dry process air filters and various accessories. The main exhibit will be the Compact type of filter, the special feature of which is an extensive area of filtering medium in compact form.

Representatives: J. L. Harpham, president; Q. G. Ewen, Verner Dahlman.

Instant Water Heater Sales Division
Booth 402
332 S. Michigan Ave., Chicago, Ill.

Insulating Products Co., Booth 199
Aurora, Ill.

International Nickel Co., Booths 48-9
67 Wall St., New York, N. Y.

This enlarged exhibit will include not only the various uses of Monel metal in power plant equipment, but also a variety of other alloys, the applications of which are rapidly expanding in this field, such as nickel bronzes, nickel cast iron, nickel steel, nickel aluminum, and heat resistant manganese-nickel; also the recently developed nickel-copper chromium cast iron (trade name Ni-Resist containing approximately 20 per cent of non-ferrous alloy.

Representatives: L. Muller-Thym, H. E. Lewis.

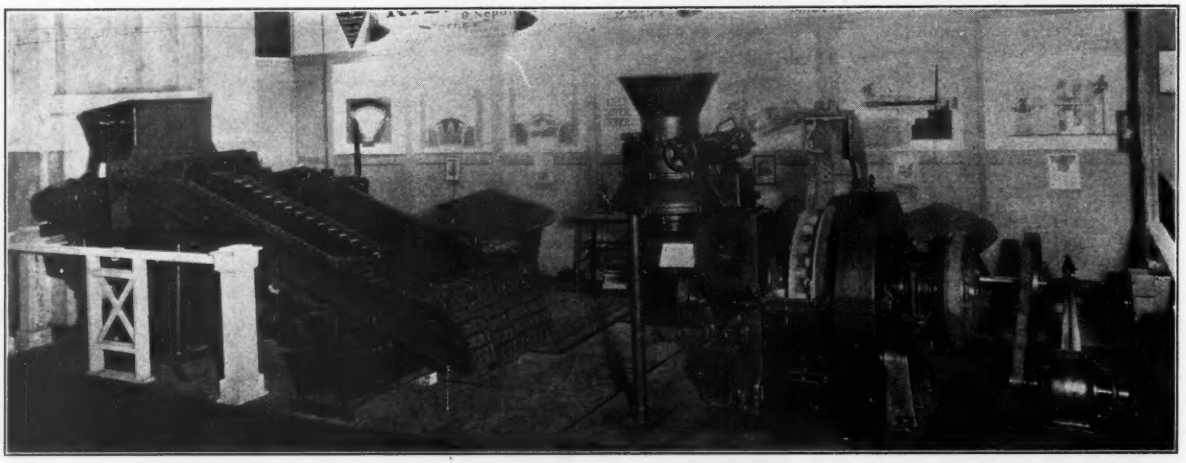
Iron Fireman Mfg. Co., Booths 222-3
984 E. 17th St., Portland, Ore.

In these booths will be displayed Iron Fireman automatic stokers operating under actual fire conditions, as well as cutaway display setups, showing every detail of automatic control features, also installation and operation of the stokers, applied to all makes of boilers, low and high pressure, under 250 hp. capacity.

Representative: J. H. Walter, national sales division; A. B. Meeg.

Irving Iron Works Co., Booth 430
Long Island City, N. Y.

Various types of open steel flooring and Safsteps for use in industrial plants, as well as the general application of Irving Continuous Armor for floors and highways will be shown. The latest developments to be exhibited will be Irving Radial Continuous illustrating fabrication of flooring



to fit platforms around tanks, vats and stacks.

Representative: P. L. Price, second vice-president, in charge.

I-T-E Circuit Breaker Co., Booths 310-11
19th and Hamilton Sts., Philadelphia, Pa.

Products to be shown will be a typical Multumite safety steel-enclosed, three-panel switchboard, including a bus tie section. This Multumite will mount hand, motor and solenoid-operated I-T-E air circuit breakers fully enclosed, equipped with primary and control disconnecting contacts and indicating lamps, to show safety, compact design, ease of installation and maintenance.

Representatives: E. Swift Newton, O. M. Bercaw, T. R. Routh, I. S. Allen, D. O. Stewart, G. R. Horne.

Jenkins Bros., Booth 318
80 White St., New York, N. Y.

Johns-Manville Corp., Booths 172-3
292 Madison Ave., New York, N. Y.

Products to be shown will include complete line of insulating materials for every industrial temperature; line of refractory cements especially developed to fill every need; standard packings, manufactured to meet every service condition; roofing, siding and other building materials.

Representative: F. W. Decker, in charge.

Johnson & Jennings Co., Booths 142-3
877 Addison Road, Cleveland, Ohio.

This company will feature the Stowe Compensated feed stoker and the J&J multi-feed stoker. These combine stationary with moving grates to maintain automatically a fuel bed of even thickness over the entire grate area so as to secure smokeless operation with any grade of coal.

Representative: L. R. Stowe, designer.

Kaye and MacDonald, Inc., Booth 61
96 Franklin Ave., W. Orange, N. J.

K-Master inverted-bucket steam trap will be shown in operation, also K & M safety trap, operating with cover removed. Cutaway models will show construction of traps and their operation.

Representatives: James W. Kaye, president; H. D. MacDonald, secretary and treasurer.

The Kelly Co., Booths 41-2
372 W. Grand Ave., Chicago, Ill.

Kerlow Steel Flooring Co., Booth 199
225 Culver Ave., Jersey City, N. J.

Klipfel Mfg. Co., Booth 411
2651 W. Harrison St., Chicago, Ill.

This display will have samples of the greater part of the company's line of automatic valve specialties.

Representative: J. H. Swan, president.

Kopperman & Sons, Booth 61
Philadelphia, Ja.

The Korfund Co., Inc., Booth 62
235 E. 42nd St., New York, N. Y.

LaClede-Christy Fire Clay Products Co.,
St. Louis, Mo. Booth 89

Ladd Water Tube Boiler Co., Booth 28
Pittsburgh, Pa.

The Leavitt Machine Co., Booth 145
Orange, Mass.

Here the company will show a complete line of the Dexter valve reseating machines for globe valves, gate valves and for refacing pump vale seats. Also will be shown for the first time the Dexter machine for Diesel engine exhaust valves and valve seats.

Representative: E. S. Hersey, sales engineer, in charge.

Ernest E. Lee Co., Booths 134-8, 144-8
115 S. Dearborn St., Chicago, Ill.

This company represents accounts listed below: Croll-Reynolds Engineering Co.; Leeds & Northrup Co.; Drake Non-Clinkering Furnace Block Co.; Atwood & Morrill Co.; Illinois Stoker Co.; Leavitt Machine Co.; Northern Equipment Co.; Uehling Instrument Co. Descriptions are given under the separate manufacturers' names.

Representatives: Ernest E. Lee, C. M. Hardin, J. L. Higgins.

Leeds & Northrup Co., Booths 138-44
4901 Stenton Ave., Philadelphia, Pa.

Following equipment will be shown: Combustion control and frequency control equipment in operation; frequency, total load, percent leakage conductivity and speed recorders; portable semi-precision potentiometer; Mueller bridge; thermometer detectors, thermocouples and generator field temperature recorder; smoke recorder. The smoke recorder measures and records the density of smoke, withdrawing a representative smoke sample continuously from the stack or breeching, passing it through a density measuring chamber and returning it to the stack. A beam of light from a lamp having automatic voltage regulation is projected through the smoke in the measuring chamber and focused on a specially constructed thermopile, the millivoltage output of the thermopile being dependent on the density of the smoke through which the light passes, and measured by a potentiometer recorder either in percent density or Ringleman chart numbers. A boiler room indicator informs the fireman at all times of smoke density in his stack. The leakage conductivity recorder is a new type during the past year.

Representatives: L. O. Heath, sales manager, general division; L. E. Emerich, district manager, general division; B. F. Keene, R. A. Mason, L. H. Coleman, H. J. W. Nethery, P. K. Welch, S. B. Morehouse, R. Cleeland, W. E. Carlson.

Lehnco Regulator Co., Booth 61
30 N. Dearborn St., Chicago, Ill.

Geo. B. Limbert & Co., Booth 118
570 Fulton St., Chicago, Ill.

Products shown and main features of the exhibit will be pipe bends, headers and pipe joints for high pressure.

Representatives: D. C. Showers, vice-president; M. R. Paulson, E. Medal; A. W. McKenney, Jr.

The Linde Air Products Co., Booths 315-6
30 E. 42nd St., New York, N. Y.

This exhibit will feature the strength and dependability of oxy-acetylene welded joints for power piping and equipment. Typical specimens of Oxwelded piping construction will be displayed, together with the newest types of welding apparatus and accessories, including the Linde liner; for welds in heavy duty piping; the Oxweld portable tensile testing machine, which will be operated to demonstrate how welds can be tested in the field; the Oxweld welding blowpipe, with attachment which converts it into a cutting

blowpipe and adaptor which makes it available for light sheet metal welding; the Oxweld oxygen welding regulator; a new machine for making ductility tests in welds; an illuminated map showing the distribution facilities of this and associated companies.

Representative: H. H. Griffith.

Link-Belt Co., Booths 96-7
910 S. Michigan Ave., Chicago, Ill.

Here will be a comprehensive display of pictures of installations of coal and ashes handling and water screening equipment in operation in the leading power generating stations, industrial power plants and public buildings throughout the country. Also operating exhibits of leading positive drives—Link-Belt silent chain, roller chain, herring-bone speed reducers and the recently announced variable speed transmission, the P. I. V. gear. An outstanding feature of the exhibit will be the recently completed operating model of the rotary railroad car dumper.

Representatives: E. J. Burnell, L. O. Millard, H. D. Mitchell, E. H. Kidder, E. A. Wendell, H. F. Weber.

Lunkenheimer Co., Booths 176-7
Cincinnati, Ohio.

The company will exhibit a 6-in. steel gate valve for each standard pressure from 150 to 1500 lb. The 900 lb. valve will be partly cut away to disclose the interior structure, the design of which is similar to that of the other valves shown. In addition will be displayed new designs of small steel globe valves, both in the inside screw and the outside screw type, embodying interesting departures from the usual practice.

Representative: William Carson, sales engineering department.

Marion Machine, Fdry. & Supply Co.,
Marion, Ind. Booth 408

Products which will be exhibited are: soot blowers, underfeed stokers and water heaters.

Representative: J. M. Wilson, Chicago branch, in charge.

Jas. P. Marsh & Co., Booths 43-4
2073 Southport Ave., Chicago, Ill.

Mason Regulator Co., Booth 402
Dorchester Center, Boston, Mass.

Mayer and Oswald Booth 199
332 S. LaSalle St., Chicago, Ill.

In this booth will be shown products of three manufacturers. Insulating Products Co. will have an exhibit of Webers 48 insulating cement and high temperature block insulation; also large photograph of a water wall insulated with the insulating cement. The Dings Magnetic Separator Co. will have on display a Magnetic Pulley type separator in operation illustrating the principle of removing tramp iron and steel from coal magnetically. The Kerlow Steel Flooring Co. will exhibit various types of steel floor grating for platforms and walkways as well as the Kerlow safety tread and concrete floor armoring.

Representatives: J. L. Mayer, F. E. Oswald, G. Stabenow.

Merrick Scale Mfg. Co., Booths 307-8
Passaic, N. J.

Here will be exhibited the Merrick conveyor Weightometer in actual operation, weighing and recording material in transit over a conveyor. Also will be shown the Merrick mechanical Weighman for weighing boiler feedwater.

Representatives: F. P. Hambridght, sales manager; T. F. Corpron, sales engineer.

Miles Engineering Co., Booths 229-30
928 Fullerton Ave., Chicago, Ill.

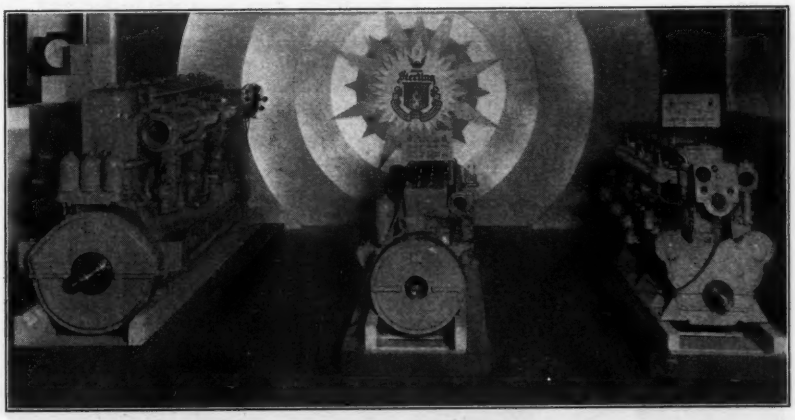
Modern Coal Burner Co., Booth 150
3733 Lincoln Ave., Chicago, Ill.

A large Modern Coal Burner and a Junior Modern Coal Burner also three exhibits of the drive unit will be shown.

Representatives: T. A. Marsh, president; J. Sherwood, chief engineer; W. P. Hullinger, sales manager.

Morse Chain Co., Booth 46
Ithaca, N. Y.

Morse Silent Chain drives, flexible couplings and chain speed reducers will be shown in actual operation to demonstrate silence, flexibility and efficiency. One unique display, through the use of a Neon lamp synchronized with the pitch travel of the chain, will permit observers to follow the true rocker action of the Morse Rocker Joint. Advances in modern chain lubrication will also be shown by the display featuring the Morse Automatic ring oiler, which delivers clean oil to the moving chain at all times.



Representatives: Earl C. Moss, Chicago branch manager, in charge; A. B. Wray, F. G. Anderson, R. J. Koch, Ithaca, N. Y.; D. I. Wheeler, C. A. Shetter, Detroit.

Motor Tool Specialty Co., Booth 83
Kenosha, Wis.

Among new developments in wrench equipment will be shown, a new set of Snap-On Giant sockets, and handles for the heaviest nut turning operations; also our new and improved design of ratchet wrenches, heavy duty Boxocket wrenches and end wrenches with short shanks, which are used on long tubular handles in sizes from $\frac{1}{16}$ to 3½-in. openings for powerful leverage and ease of operation on large nuts and bolts in hard-to-reach locations. Full line of Blue Point engineer's wrenches from the smallest to the large sizes, adjustable-end wrenches, pipe wrenches, wheel pullers, mechanic's hammers, screw drivers, chisels and punches, and other tools required in the repair and maintenance of machinery will be displayed. A feature will be an electrically-operated display to picturize service maintained through twenty-eight distributing warehouses.

Representatives: Stanton Palmer, presiden; N. E. Tarble, general sales manager; Joseph Johnson, vice-president and treasurer; C. H. Tennyson, experimental engineering department; C. W. Edwards, Chicago branch manager.

J. W. Murphy Co., Booth 312
431 S. Dearborn St., Chicago, Ill.

Nash Engineering Co., Booths 76-9
So. Norwalk, Conn.

National Aluminate Corp., Booth 60
6216 W. 66th Place, Chicago, Ill.

Use of KWS sodium aluminate for scale reduction and removal will be demonstrated in this space, the details of this system of water treatment for external and internal treating for steam plants and for distilled or raw water ice plants, being fully explained. Also will be shown the National Continuous Blowdown and heat reclaimer.

Representatives: E. F. Fellows, H. A. Gustin, J. A. Holmes, L. D. Kensig, F. H. Thorne, A. E. Warner.

National Power Construction Co.,
20 N. Wacker Drive. Booth 152

This exhibit will consist of a displayed list of power plant projects worked on by the company since the last Power Show. Also several interesting pictures of recent installations, showing the trend of modern boiler settings in central stations.

Representatives: A. L. Scheying, Glenn E. Reynolds, William H. Matthews.

National Tube Co., Booths 301-2
1802 Frick Bldg., Pittsburgh, Pa.

Norma-Hoffman Bearings Corp.,
Stamford, Conn. Booths 33-4

Samples will be exhibited of the complete range of ball, roller and thrust bearings. Also will be displayed the new GreaSeal felt protected ball bearings for small bearings to eliminate the cost of protective devices by means of the felt washer held between retaining plates, which are rigidly fastened to the outer ring of the bearing.

Representatives: T. J. Harley, Chicago district manager in charge; H. J. Ritter, assistant secretary; D. E. Batesole, assistant engineering manager; D. W. Robinson, C. H. Wallace, T. M. Kaino, sales representatives.

Northern Equipment Co., Booths 147-8
Erie, Pa.

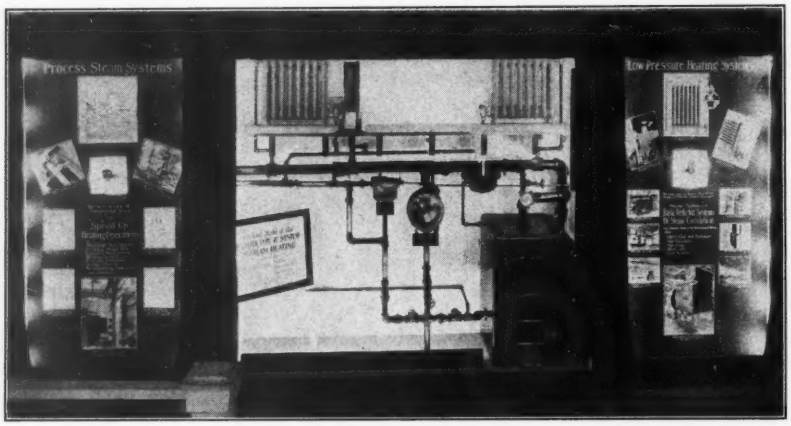
Featured in this display will be a demonstration and explanation of an excess pressure control in the boiler feed line. An exhibit board will demonstrate the whys and hows of differential water pressure regulation as used in modern power plants. Copes feedwater regulator and Copes differential water pressure regulating valve will be shown installed in the fed line to a typical boiler. Equipment will be full size and cutaway so that operation can be readily seen, while meters will show load and water flow and a continuous chart will give pump pressure, regulator inlet pressure and boiler pressure, reproducing the action of the equipment under conditions of changing

boiler loads. A Copes valve movement indicator will show how the regulator valve opens and closes in accordance with changes in boiler water level. Another feature will be the Copes RG valve with the excess pressure control valve in a single compact body; the Copes pump governor and Copes type CRI valve for high-pressure condensate drainage control will also be exhibited.

Representatives: E. W. Nick, president; V. V. Veenschoten, C. E. Wolff, Jr., K. B. Whitley, Don Allshouse.

Wm. W. Nugent & Co., Inc. Booth 59
410 N. Hermitage Ave., Chicago, Ill.

Products exhibited will be working models of gravity and pressure types of oils filters and pumps; full size sight feed valves and sight flow indicators; telescopic and multiple oilers; compression union threadless pipe fittings; oil pumps, crank pin oilers, oil level gages and oil fittings.



Representatives: Wm. W. Nugent, Corliss D. Nugent, John Vocelka.

Nye Tool & Machine Works, Booth 337
4120 Fullerton Ave., Chicago, Ill.

Portable pipe threading and cutting machines, also hand threading and cutting devices will be shown.

Representatives: Harry G. Nye, O. S. Lee, T. M. Lilleberg, William Clement.

Oakite Products, Inc., Booth 12
22 Thames St., New York, N. Y.

The S. Obermayer Co., Booth 456
2563 W. 18th St., Chicago, Ill.

Following products will be exhibited: Ramtite plastic furnace lining, Hott-Patch Patented high temperature cement, Esso Bond No. 40 high temperature cement. The main feature of the exhibit will be a demonstration of the methods and equipment used for the completely mechanical installation of unshaped plastic firebrick, developed so that a new and efficient type of anchor can be used and the entire lining can be packed to exactly the right density. Also will be exhibited the new container for Ramtite, a rectangular waterproof carton which holds 100 lb. (three-quarters of a cubic foot), to keep the material in better condition, easier to handle and store especially in cramped quarters, and prevent waste of material.

Representatives: George F. Doyle, D. J. McGowan, S. I. McQuilken, H. M. Graff, George Campbell, Theodore Kauffman, Jr., manager.

Old Ben Coal Corporation, Booth 400
230 S. Clark St., Chicago, Ill.

Stoker coals both from Illinois and the east will be featured at the Old Ben booth, with special emphasis given to a patented process which the corporation uses to clean its small size coal in Franklin Co., Illinois.

Representatives: Herbert Eggert, combustion engineer; John W. Lucas, sales engineer; Walter O'Brien, assistant sales manager; Robert A. McMahon, publicity department.

The Parker Appliance Co., Booth 209
10320 Berea Rd., Cleveland, Ohio.

Parker tube couplings, flaring tools, bending equipment, power plant blowdown lines, high-pressure tube couplings and the latest types of couplings will be shown. Feature will be 4-in. tube couplings for water works in power plants and other industrial enterprises; also a Parker Triple coupling for close quarter work. Parker tube couplings will be shown in brass, steel and monel, for high and low pressures. Condensation coils in various stock sizes will be included.

Representative: W. F. Rapprich.

Perfex Corp., Booth 425
Milwaukee, Wis.

Products shown will include a full line of newly developed unit heaters, also blast cores for process drying and heating.

Representatives: T. C. Cornell, sales manager, heating division; Albert Orndorf, Milwaukee.

The Permutit Co., Booths 163-4
440 Fourth Ave., New York, N. Y.

The principal type of equipment shown will be as follows: Permutit Water softener with section cut away to show beds of gravel and zeolite and features of Permutit design. Electro-Chemical feeds with swing drawoff pipe: type B for proportionating; type C for adjustable, automatic start and stop. Ranarex CO_2 indicator and recorder, the new model being in operation, for recording the specific gravity of gases and for butane-air mixing. Permutit continuous blow-off equipment.

Representatives: F. S. Dunham, H. P. Sherwood I. J. Bready, H. J. Keays, R. S. Ellis, B. F. Soffe, H. G. Taylor, J. R. Crocker.

Plibrico Jointless Firebrick Co., Booths 130-2
1800 Kingsbury St., Chicago, Ill.

This company will exhibit Plibrico furnace lining in its various applications together with examples of boiler setting construction. Also the Beco Turner baffle which is sold by the Boiler Engineering Co.

Representative: Frank S. Reeder, assistant sales manager.

William A. Pope, Booth 81
26 N. Jefferson St., Chicago, Ill.

This space will be used as a meeting place for the friends of Mr. Pope and his organization to discuss methods of modern piping installation and to explain the work which they have done in installing and remodeling large plants.

Representatives: William A. Pope, William H. Miller, R. A. Widdicombe, S. Austin Pope.

William Powell Co., Booths 114-5
2521 Spring Grove Ave., Cincinnati, Ohio.

Main features will be special alloy valves and electric motor-operated valves. Complete line of bronze, iron and steel valves in globe, angle, gate, check and safety patterns will be shown.

Representatives: E. F. Smith, Chicago representative, in charge; James Coombe, E. R. Noll, William Heilig.

Power Plant Specialty Co., Booth 38
440 S. Dearborn St., Chicago, Ill.

Products shown will be: a chemical proportioner, a steam separator, and a line tank agitator. Also will be exhibited mounted blueprints showing conventional arrangements of the water softener equipment as offered to the trade.

Representatives: W. H. Stevenson, president; M. B. Peirson, secretary; N. W. Hobson, engineer.

Power Plant Engineering, Booth 54
53 W. Jackson Blvd., Chicago, Ill.

The Powers Regulator Co., Booth 455
2720 Greenview Ave., Chicago, Ill.

The Rawlplug Co., Inc., Booth 219
98 Lafayette St., New York, N. Y.

Rawlplugs which are screw anchors made of jute fibre requiring a hole scarcely larger than the screw itself, so that, when the screw enters the Rawlplug it is tightly compressed against the sides of the hole for the full length of the thread will be demonstrated. The Rawldrill which has been developed to meet the demand for a fast-cutting masonry drill, that can be resharpened or dressed right on the job by the mechanic using it, will be exhibited. The Crowner and Lok-Crowner is a new device on the market to be used as a protection for the head of the screw besides being ornamental.

Representatives: H. G. Janton, exhibit manager; E. H. Dicker, Chicago representative.

Reeves Pulley Co., Booths 139-40
Columbus, Ind.

This will be a running display of Reeves variable speed transmissions, the feature of which will be several new designs, including a completely enclosed design, electric automatic control, electric-remote control and completely enclosed vertical design.

Representatives: C. M. Reeves, vice-president; A. E. Shibley, Chicago branch manager; E. T. Moore, H. M. Glessner, E. C. Schrade.

Republic Flow Meters Co., Booths 68-9
2240 Diversey Parkway, Chicago, Ill.

Complete line of power plant and industrial instruments will be distributed, including flow meters, CO_2 meters, draft instruments, liquid level gages, pressure gages, pyrometers and control pyrometers. Working models will be specially featured showing the latest developments in flow meters, CO_2 meters and control pyrometers in operation; also will be shown large steel boiler panels and master panels with various combinations of flush mounted instruments and a variety of individual instruments.

Representatives: James D. Cunningham, president; J. M. Spitzglass, vice-president; G. S. Hendrickson, sales manager; H. H. Skabo, Indianapolis; R. C. Ascher, Detroit; S. C. Vail, W. L. Eckdhal, T. E. Bell, A. Heuring, Chicago; C. G. Armstrong, St. Louis; K. B. Roudebush, Cincinnati.

J. E. Rhoads & Sons, Booths 327-8
35 North Sixth St., Philadelphia, Pa.

In operation will be a testing machine to show the relative efficiency of flat leather belting (of Rhoads manufacture in particular) as compared with fabric belts, also a machine which will show the relative pulling capacity of Rhoads' Tannate flat leather belting and oak leather belting, friction surface rubber and red stitched canvas. Display will be made of miscellaneous products, a section of 76-in. 4-ply Tannate Watershed belting to show its construction and a special fabric belt, Rhoads Speedolite for use on high speed drives over small pullevs or spindles where loads are comparatively light.

Representatives: W. J. Coppock, in charge; G. A. Hoopes, S. A. Rohde, S. A. Braude.

Richardson Scale Co., Booth 462
Clifton, N. J.

Riley Stoker Corp., Booths 153-5
Worcester, Mass.

This company will exhibit the new type No. 4 Riley pulverizer, also a new type Riley cyclone burner and a new Jones side dump stoker with moving combustion grates. The exhibit will be so arranged that the operation of all apparatus can be demonstrated.

Representatives: Robert J. Kruger, advertising manager, in charge; C. L. Smith, M. L. Cornelious, W. C. Armstrong, A. G. Shelley.

Rollway Bearing Co., Inc., Booth 186
Syracuse, N. Y.

Various types of heavy duty bearings will be shown including the new maximum floating type for use in large, heavy mechanisms. The operation of this particular bearing will be demonstrated in a full size crane end.

Representatives: H. E. Stratford, Chicago, in charge; C. O. Cromwell, Detroit; Samuel Farrell, Pittsburgh.

Sarco Company, Inc., Booth 26
183 Madison Ave., New York.

Products exhibited will be samples of the full Sarco line, comprising thermostatic steam traps for heating and process work, also combination float-thermostatic traps, strainers and temperature regulators.

Representatives: George H. B. Burke, F. H. Sprague, E. M. Mittendorff, H. C. Shilling.

Sauerman Bros., Booth 167
438 S. Clinton St., Chicago, Ill.

This exhibit will deal with the Sauerman power drag scraper systems for storing and reclaiming coal and other bulk materials. An outstanding feature of the display will be a working model showing complete Sauerman power drag scraper installation in service.

Representatives: John A. Schultz, R. H. Baughman.

Schutte & Koerting Co., Booth 45
12th and Thompson St., Philadelphia, Pa.

Products here shown will include SK steam jet specialties for power and process work, a newly developed electrical control for motor-operated reducing valve governors and the like. This control in operation, will be exhibited in connection with a large sectional diagram of the SK motor-operated venturi reducing valve. The SK hydraulically-operated venturi reducing valve will be shown in the same way. A few models and a complete set of descriptive literature will be displayed.

Representatives: A. C. Nell, Chicago district manager, in charge; R. H. Groff, sales engineer.

Shafer Bearing Co., Booth 19
6501 W. Grand Ave., Chicago, Ill.

Shepard Niles Crane & Hoist Corp.,
Montour Falls, N. Y. Booth 300

Two of the new design compact hoists, one of the close clearance type equipped with new design of motor-driven trolley will both be shown in operation. In addition will be photographic enlargements showing the complete line from ¼-t. hoists up to overhead electric traveling cranes of 450 t. capacity.

Representatives: Robert T. Turner, vice-president; W. B. Briggs, G. G. Robbins, H. A. Baugh.

D. H. Skeen & Co., Booths 74, 75
1 La Salle St., Chicago, Ill.

This company will act as manufacturers representatives for the following firms and products: Air Preheater Corp., Ljungstrom air preheaters; Allen-Sherman-Hoff Co., ash and dust handling, coal bunkers, Hydroseal pumps; American Arch Co., air cooled walls and arches; Connery & Co., Inc., breechings, uptakes and ducts; Cutler-Hammer, Inc., electric valve controls; Dust Recovery, Inc., dust collectors; Edward Valve & Mfg. Co., forged and cast steel valves; Electric Indicator Corp., signal and position indicators; M. W. Kellogg Co., welded drums and pipes; Limitorque Corp., valve controls; Mercon Regulator Co., pressure and flow regulators, filling and drainage controllers; National Co., water column illuminators; Stets Co., water level and drainage controllers.

Representative: M. G. Hughes.

S.K.F. Industries, Inc., Booths 24-5
40 E. 34th St., New York, N. Y.

Skidmore Corp., Booths 189-90
St. Joseph, Mich.

Four sizes of vacuum pumps from 5000 lb. to 100,000 lb. capacities and a line of condensation pumps and receivers will be exhibited.

Representatives: B. Skidmore, Jr., V. D. Milliken, W. S. Logan E. E. Maher.

C. E. Squires Co., Booth 36
E. 40th St. and Kelley Ave., Cleveland, O.

Genuine Squires steam traps and reducing valves will be featured at this exhibit.

Representative: Mr. Ogden.

Standard Oil Co., Booth 37
910 S. Michigan Ave., Chicago, Ill.

Lubricants for use on every type of equipment used in power plants will be included in this exhibit. The proper grade of lubricants, oils and greases for correctly lubricating each particular equipment will be indicated.

Representatives: C. G. Kustner, R. E. Vogel, B. L. Patton, M. L. Simmon, J. H. Flannigan.

Stephens-Adamson Mfg. Co., Booth 184
Aurora, Ill.

This company will show its line of JFS variable speed reducers, also conveyor carriers for belt conveyors. The special feature of the exhibit will be the new motorized JFS, which consists of a variable speed reducer combined with an electric motor of standard manufacture. The unit is entirely self-contained so that the entire drive can be mounted with but four base bolts with no base plates, alinement difficulties, gear noises, open gears or exposed couplings.

Representatives: C. H. Adamson, secretary; E. J. Patton, advertising manager; R. S. Jacobsen, L. V. Lindquist, J. A. Phillips, T. A. Ruddy, A. D. Sinden, P. B. Shepard.

Sterling Midland Coal Co., Booth 443
343 S. Dearborn St., Chicago, Ill.

Strom Bearings Co., Booth 20
4527 Palmer St., Chicago, Ill.

This company will display its complete line of Strom and M-R-C high-grade ball bearings, including single and double row annular types, as well as thrust types.

Representatives: M. E. Monk, director of sales; E. H. Rahn, assistant director of sales; H. N. Parsons, chief engineer; H. R. Higgins, L. Anderson, sales engineers.

The Strong-Scott Mfg. Co., Booth 185
Minneapolis, Minn.

Revised, revamped and completely up-to-date model of pulverizer embodying all recent detail improvement will be demonstrated, together with photographs of typically outstanding installations.

Representatives: Homer L. Rank, Unipulvo sales manager; A. W. Strong, H. G. Lykken, Minneapolis; George W. Heald, Karl Schmidt, Chicago.

Sumet Corp., Booth 188
1543 Fillmore Ave., Buffalo, N. Y.

Five bearings of Actenized Sumet bronze will be shown in operation, making a unique display. A cold rolled steel shaft will run at 3,000 r.p.m. at 600 deg. F., the temperature being shown by a thermometer; another shaft will be run dry and another with steam lubrication only at 215 deg. Two will be shown as a test for water lubrication only.

Representatives: H. O. Warner, sales manager; A. A. Matthews, sales engineer.

The Superheater Co., Booths 124-5
60 East 42nd St., New York, N. Y.

In addition to panels showing superheater construction, will be on exhibit a one-sixteenth actual size model of one of two 1400-lb. semi-vertical boilers with Elesco superheaters now being installed at the Fordson Plant of the Ford Motor Co., Detroit. These superheaters are designed to handle 700,000 lb. of steam per hr. at 1350 lb. pressure, raising the temperature 168 deg. F., to a final temperature of 750 deg.

Representatives: R. M. Gates, vice president; C. W. Gordon, W. C. Conlon, R. S. Cooper, J. A. Robe.

Superior Engine Co., Booths 31-2
Springfield, Ohio.

This company will exhibit two engines, a six cylinder stationary Diesel of 210-hp. at 600 r.p.m., 8½ in. bore, 11 in. stroke, weight 12,500 lb. Also a 33-kw. Diesel generator set with three-cylinder 50-hp. Diesel engine, 720 r.p.m., 6½ in. bore, 8 in. stroke. These engines are of the four-cycle type, with new features to give flexibility and quick acceleration, with governor control at all speeds from 150 to 700 r.p.m. They have constant pressure, mechanical fuel injection by plunger pumps driven by cams to deliver fuel into the high-pressure manifold from which branch oil lines of equal length connect to spray plugs in the centers of cylinder heads. Two hand levers start the engine and control the speed.

Representative: E. Opferkuck, sales manager, in charge.

The Swartwout Co., Booths 50, 51
18511 Euclid Ave., Cleveland, Ohio.

This year an extensive line of power plant equipment will be shown. Featured particularly are the S.C. combination feed water regulator and continuous blowdown valve; the Swartwout desuperheating and pressure-reducing station will be of equal interest. Included in the exhibit also will be pump governors, master regulators, steam separators, exhaust heads, steam traps of all types and feed water heaters, as well as the Swartwout Rotary ball bearing roof ventilators.

Representative: H. C. Miller.

Webster Tallmadge, Inc., Booth 61
50 Church St., New York, N. Y.

The Texas Co., Booth 305
332 S. Michigan Ave., Chicago, Ill.

Lubricating oils and greases for industrial plants will make up the display in this space to show the adaptability of various lubricants for different purposes.

Representatives: A. J. Herom, lubricating engineer, in charge.

Timken Roller Bearing Co., Booth 414
Canton, Ohio.

The company's exhibit will consist of an assortment of bearings suitable for various purposes, including a steel-mill-roll neck bearing, and one of the type developed for railway service.

Representatives: G. D. Thewlis, Chicago district manager of industrial sales; H. W. Trump, W. F. Anderson, industrial sales, Chicago.

Tube Turns, Inc., Booth 61
Louisville, Ky.

Uehling Instrument Co., Booth 147
473 Letty Ave., Paterson, N. J.

A new potentiometer just on the market, also a combined barometer and vacuum recorder for condensers and vacuum shells will be shown. Perfected Apex CO_2 equipment, electrically operated, will be displayed with vacuum pump and oil regulator, eliminating steam, water, exhaust and drain lines.

Representative: C. J. Schmid, in charge.

Universal Bearing Metals Corp.,
258 State St., Rochester, N. Y. Booth 84

As sole producer of Bearium metal, this company will, during the exhibition, demonstrate the non-seizing, non-scoring and long life properties of this metal, samples of its various forms being included in the exhibit, such as machined bushings and a recent development of impregnating with a material that gives lubricating properties.

Representative: R. W. Balam, in charge.

Van Dorn Electric Tool Co., Booth 340
Towson, Md.

This exhibit will be with the Black & Decker Mfg. Co. of Black & Decker-Van Dorn high-cycle tools and foundry grinders, also portable electric tools.

Representatives: A. M. York, Chicago manager; G. J. Coffey, in charge; E. W. Ristau, W. H. Wahlen.

Henry Vogt Machine Co., Booths 207-8
Louisville, Ky

Products shown will include drop forged steel and stainless steel flanged and screw end valves and fittings.

Representatives: G. A. Daeuble, Jr., W. S. Cannon, Jr., L. D. Schlegel, W. A. Jackman, E. G. Staley, L. W. Horr.

The Vulcan Soot Cleaner Co.,
DuBois, Pa. Booth 160

Vulcan ratchet and valve operating heads will be shown in operation on a section of boiler wall; also various parts of the Vulcan cleaner such as elements, clamps, bearings and wall sleeves.

Representatives: William C. Ihde, general sales manager; C. L. Burnham, Chicago; P. F. Branston.

J. D. Wallace & Co., Booth 322
134 S California Ave., Chicago, Ill.

Main features of the exhibit will be portable electric saws, jointers, band saws, radial saws, oilstone grinders, shapers; also automatic heat controlled glue pots and an "eight machines in one" woodworker for the man with a hobby.

Representatives: J. H. Roberts, Chicago district sales manager; R. Reinhartsen, H. G. Krebs.

Walworth Co., Booths 101-3
Statler Bldg., Boston, Mass.

Here will be featured a new line of Walworth lubricated plug valves and the new Walco wrench, in addition to bronze, iron body and Sigma Steel valves. The lubricated plug valves, as made by Walworth, will be shown for the first time at Chicago. They include valves for working steam pressures up to 250 lb., at temperatures up to 600 deg. F. and for hydraulic non-shock pressures up to 500 lb. at ordinary atmospheric temperatures. The Walco wrench is a pipe tool recently developed, which consists of only four parts, with the handle and frame integral, of drop forged steel. Tests to demonstrate the strength and ease of operating this wrench will be put on in the booth and will also be shown in moving pictures. The valve display will include complete line of bronze steam valves for pressures up to 300 lb., Sigma Steel valves for 150, 400, 600, and 900 lb. with Nitralloy and Monel trims.

Representatives: F. W. Duemler, vice president; C. W. Watson, assistant sales manager; C. L. Wilkins, Chicago manager; Henry G. Lambert, tool division.

Weber Insulations, Inc., Booth 234
East Chicago, Ind.

Weil Pump Co., Booth 29
325 W. Huron St., Chicago, Ill.

The following units will be shown: Electric Water Boy cellar drainer, with all parts below and including the floor plate galvanized; 6-in. vertical Non-Clogging ejector with bronze impeller; 3-in. horizontal ejector; 2-in. ball bearing, horizontally-split case all bronze unit with motor; 4-in. ball bearing, horizontally-split case pump without motor; horizontal condensation pump and receiver; 2½-in. ball-bearing opposed-suction 2-stage pump, showing casing open; 2½-in. opposed-suction ball-bearing 4-stage unit, casing made of semi-steel with nickel steel bolts with 1,000 lb. pressure gage and hand pump; ball-bearing, vertically-split-case, horizontal pump.

Representatives: J. E. Vitu, chief engineer, in charge; N. H. Weil, Ralph D. Weil, George W. Weil, R. T. Sheridan.

Westinghouse Electric & Manufacturing Co., Booths 109, 110, 112
East Pittsburgh, Pa.

The product to be featured is a working model of a single retort stoker.

Representatives: A. F. Strouse, stoker sales, Philadelphia; T. W. Merrill, Chicago.

Weston Electrical Instrument Corp., Booth 450
614 Frelinghuysen Ave., Newark, N. J.

Representative display will be made of both switchboard and portable A. C. and D. C. indicating instruments. A feature will be a working demonstration of the Weston electrical tachometer, designed for the accurate measurement of rotational speeds.

Representatives: H. M. Ricks, C. B. Denton, Newark. N. J.; Kline Gray, J. F. Inman, P. A. Westburg, A. H. Thielke, Chicago representatives.

Whiting Corporation, Booths 92-3
Harvey, Ill.

Whitney Metal Tool Co., Booth 325
Rockford, Ill.

Hand metal working punches and angle iron machinery, also a power punch, as well as a complete line of other labor saving tools will be shown.

Representatives: John Jensen, Gus Jensen, Howard Blade.

The Wickes Boiler Co., Booth 166
Saginaw, Mich.

The exhibit will include photographs and drawings showing many installations and various types of Wickes boilers.

Representatives: C. F. Wilson, M. S. Nelson, E. A. Dunton.

L. J. Wing Mfg. Co., Booth 424
154 W. 14th St., New York, N. Y.

Wing products including Featherweight unit heaters of vertical and horizontal types with the new hairpin type high-pressure heating element will be shown; also turbine blowers for forced draft service for stokered or hand-fired boilers, turbine blowers for gas producer service, motor-driven blowers for burning cheap coals in low-pressure heating boilers, Wing-Scruplex fans and exhausters for ventilation problems of all types and for removing large volumes of odors and vapors.

Representatives: Alfred E. Seelig, president; Harry S. Wheller, vice-president; C. W. Diemecke, Chicago representative.

Wright-Austin Co., Booth 87
315 W. Woodbridge St., Detroit, Mich.

Cut-open models will be shown of regular products and as new features will be seen the Airxpel trap in forged steel, inclined mounting for boiler water gages, a new strainer and a forged steel water column with Kleervu gage glass protector.

Representatives: C. Burt Walker, president; C. G. Heydon, factory representative; H. R. Patterson, Chicago representative, in charge.

Wright Mfg. Co., Booth 434
929 Connecticut Ave., Bridgeport, Conn.

Products to be shown will be new line of hook suspension and plain geared and motor driven electric hoists.

Representatives: R. F. Straw, E. B. Low, C. P. Moessner.

Yarnall-Waring Co., Booths 107-8
Chestnut Hill, Philadelphia, Pa.

Full line of Yarway Tandem blow-off valves for all working pressures up to 2000 lb. will be exhibited, including sectioned samples. Also various types of Yarway Floatless Hi-Lo alarm water columns and Yarway Sesure inclined gages, using both round and flat glasses for low and high pressures. A Yarway cylinder-guided expansion joint will be sectioned to show internal construction. Yarway hydraulic valves of single and two pressure types for pressures up to 5000 lb. will be displayed.

Representatives: H. J. Moyer, Chicago district manager; E. W. Zimmermann, sales engineer; A. L. Aicher, mechanical engineer.

News Notes

INDEPENDENT AIR FILTER Co. has been organized with office and factory at 29 South Clinton St., Chicago, Ill., to manufacture and sell a full line of air filtration equipment. The initial product is the Compact filter, a dry fabric filter, with extensive area of filter material in compact form, for general ventilation, industrial air cleaning, air compressors, Diesel engines and domestic warm air furnaces. Other types will be added to the line later.

READING IRON Co., Reading, Pa., announces the appointment of F. W. Deppe, formerly district sales representative at St. Louis, Mo., as general manager of sales, with offices at 230 Park Ave., New York, N. Y.

C. H. WHEELER MFG. Co. announces that P. A. Thompson has recently taken charge of their Heat Transfer Equipment Division and will be located in its main office at Philadelphia, Pa. F. A. Faville has joined this company as manager of its Chicago office located at 1122 Marquette Building, Dearborn and Adams Sts., Chicago, Ill.

KENNEDY VALVE MFG. Co. announces the appointment of John J. Foy as its Southern California representative, with headquarters at 210 Transportation Building, Los Angeles, Calif.

ANNOUNCEMENT is made that Southwark Foundry & Machine Co. will transfer the major portion of its assets to Baldwin-Southwark Corp., as of Dec. 31, 1930. The latter organization has assumed all outstanding liabilities and will carry on the entire business formerly done in the name of the former. All future communications pertaining to matters formerly affecting Southwark Foundry & Machine Co. should be addressed to Baldwin-Southwark Corp., Paschall Station Post Office, Philadelphia, Pa., and all statements should be rendered and all checks made payable to that corporation. There will be no change, it is stated, in the Southwark management, sales or engineering personnel.

PLIBRICO JOINTLESS FIREBRICK Co., Chicago, Ill., announces the appointment of L. R. Land, % O. K. Transfer & Storage Co., 531 West Main St., Oklahoma City, as its representative in Oklahoma.

HIMELBLAU, AGAZIM & Co., 30 N. Dearborn St., Chicago, Ill., advises that it is moving its pipe welding and fabricating shop to the Central Manufacturing District at 74th and Ashland Ave., Chicago, Ill., where it will have greater facilities.

ANNUAL BANQUET of Morse Chain Co. executives, superintendents, office men and foremen was held in Ithaca, N. Y., on Dec. 9, 1930. About 200 men attended, the principal speaker being Frank L. Morse, president and treasurer of the organization.

ANNOUNCEMENT has been made that, effective January 1, 1931, those units of Union Carbide and Carbon Corp. whose products are used in the main for oxy-acetylene welding and cutting are to market their products through The Linde Air Products Co. for the convenience and economy of the users of these products. Telephone numbers or addresses of the distributing stations are not changed and orders will be taken as heretofore.

HAYS CORP. of Michigan City, Ind., has begun construction of a new steel and brick foundry building adjoining its present factory to provide an additional 6000 sq. ft. of space for the manufacture of its products.

UNITED CONVEYOR CORP., Chicago, Ill., announces the opening of a New York Office at 101 Park Ave. This office will be directed by J. J. McNulta, who will be in charge of the New York and New England districts.

STARKWEATHER & BROADHURST, INC., 79 Milk St., Boston, Mass. has been appointed sales representative in New England by the Murray Iron Works Co., Burlington, Iowa.

LINK-BELT Co., Chicago, announces the appointment of the McFarland Tractor & Equipment Co., St. Joseph, Mo., as agent for the sale of its cranes, shovels, draglines, for the territory of Atchison and Doniphan counties in Kansas and the 17 counties in northwestern Missouri, around St. Joseph.

Catalog Notes

TAYLOR STOKER is completely described in a recent 24-page bulletin, illustrated in colors, by the American Engineering Co., Philadelphia, Pa. Fundamental considerations of stokers are first discussed, followed by details of the various parts of the stoker, methods of cleaning and driving, methods of ash disposal, the type M stoker with straight line drive, methods of handling air for combustion and so on. In another 24-page bulletin, the company discusses Burning Coal the Modern Way with Taylor Underfeed Stokers. This gives data on the construction of the stokers, operating results from various plants in which they are installed and data on various types of fuels that have been burned on them. A 24-page illustrated bulletin just issued by the company discusses Zoned Water Cooling and Armored Furnaces. This shows by text, line drawing and photograph, the construction and method of installation of A-E-Co furnace armor and water-cooling tube under all types of stoker firing conditions.

FUSION WELDING is discussed in a new bulletin issued by The Babcock & Wilcox Co., 85 Liberty St., New York. This publication discusses a new method of welding which, the company states, eliminates the necessity for long training or great skill on the part of the operator and produces welds equal to or better than the work metal in tensile strength, shock resistance, ductility and the ability to withstand repeated stresses. These characteristics are illustrated by photographs and descriptions of test specimens, chemical analysis, macrographs and photomicrographic studies. A chapter of this bulletin is devoted to the non-destructive tests employed by The Babcock & Wilcox Co. to prove the efficiency of welded seams in finished products without damage to the product in any way. Photographs of X-ray studies are shown and a new electro magnetic tester is described which hunts out defects in welds and records their presence on a graph. The bulletin also shows how these non-destructive tests have been checked and verified.

MECHANICALLY OPERATED FLUID METERS are described in a new bulletin No. 37 by the Bailey Meter Co., Cleveland, Ohio. This bulletin describes and illustrates various types of mechanically operated meters and the auxiliary equipment for their installations Colored charts show results obtained with them in various processes and data are given on orifices and flow nozzle location, calibration, pulsating flow, special conditions and special applications.

AN OLD NAME ON NEW PRODUCTS is the title of a recent bulletin issued by the Borden Company, Warren, Ohio. This describes and illustrates recent new products of the company, some of which, such as the new Beaver 4-poster Ratchet tool, the new No. 104 Beaver Square end pipe cutter and the 3-way ratchet tool, have been described recently in Power Plant Engineering. Other new products are described such as the No. 8 Beaver, the new 41-E geared die stock for 2½ to 4 in. pipe, the new No. 102 wheel cutter and the No. 17 ratchet die stock.

PERMUTIT CONTINUOUS BLOWOFF SYSTEMS are fully described in a recent 20-page illustrated bulletin by the Permutit Co., 440 Fourth Ave., New York City. This bulletin discusses the installation of the system, why it is needed and how it works, operating difficulties and heat losses of intermittent blowoff, and a description of continuous blowoff systems for evaporators.

IN A RECENT 24-page booklet, recording gages with steel springs having all steel, all welded movements to give long life and better service, are fully described by the Foxboro Co., Foxboro, Mass.

IN ITS NEW HANDBOOK of Variable Speed Control, a cloth-bound, 72-page booklet, the Reeves Pulley Co., Columbus, Ind., discusses the need for variable speed control, application of the control, detailed description of various forms of the Reeves variable speed transmission and presents engineering data on selection of units, drives, designs, controls operation and care and other engineering information.

LEAFLETS DESCRIBING the application of Carbex bricks and blocks for high temperature furnace lining, also on Steel Mixture fire brick and cement for standard furnace lining requirements have just been issued by McLeod & Henry Co., 29 Monroe St., Troy, N. Y.

EVERLASTING VALVE, weight operated with pendulum stop for fire protection and Everlasting special water column valve for connection between boiler and water column are described in recent folders issued by Everlasting Valve Co., Jersey City, N. J.

DUPLEX AIR AND GAS COMPRESSORS are discussed in detail in bulletin No. 151, a recent 24-page publication of the Pennsylvania Pump & Compressor Co., Easton, Pa. Details of frames, bearings, shaft, cylinders and other parts are treated fully, as well as the subject of inter-coolers and after-coolers, automatic protection and methods of driving.

HANDBOOK OF CRANE INFORMATION, compiled by M. F. Beetham, Crane Engineer, has recently been issued by Whiting Corp., Harvey, Ill. This is a 150 page illustrated book bound in leather and priced at $2.00. It discusses how to select a crane, classification of type, clearances, speeds, runways, crane bridges and trolleys, bucket handling cranes, hand power traveling cranes, jib cranes, lifting attachments, electric equipment, erection and lubrication of cranes, specifications and safety features. It is well illustrated with photographs of details and actual installations and engineering data on installation and operation are presented by drawings, charts and tables.

Power Plant Construction News

Ala., Huntsville—The Alabama Power Co., Birmingham. is said to be planning extensions and improvements in power station and system at Huntsville, to cost over $100,000.

Calif., Avon—The Associated Oil Co., Associated Oil Building, San Francisco, has awarded a general contract to C. C. Moore Co., Sheldon Building, San Francisco, for a boiler plant in connection with an expansion program at oil refinery at Avon, entire project to cost close to $1,500,000.

Calif., Isleton—The Isleton Canning Co., plans installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss reported in excess of $125,000.

Calif., Stockton—The Holly Sugar Co., Colorado Springs, Colo., plans installation of electric power equipment and construction of power house at proposed beet sugar mill, now being projected, near Stockton, entire plant to cost more than $1,000,000. Company engineering department will be in charge.

Del., Farnhurst—The Board of Governors, Delaware State Hospital, Farnhurst, is reported arranging an appropriation of $28,000 for an addition to the boiler plant at the institution.

Ga., Austell—The Clark Thread Co., 260 Ogden Street, Newark, N. J., plans the construction of a power plant and pumping station in connection with proposed new thread mill at Austell, about 16 miles from Atlanta, entire project to cost over $1,500,000. J. E. Sirrine & Co., Greenville, S. C., are architects and engineers.

Ga., Savannah—The Pineland Products Co., Augusta Road, plans installation of electric power equipment in connection with proposed rebuilding of a turpentine distilling plant, recently destroyed by fire with loss reported in excess of $60,000.

Ill., Joliet—The Flint Sanitary Milk Co., 409 Collins Street, is said to be planning the installation of electric power equipment in connection with a projected plant addition to cost about $200,000. It is understood that an architect will soon be selected.

Iowa, Mount Pleasant—The City Council is said to be planning the installation of additional equipment in municipal electric light and power plant, including a turbine-engine unit and accessories, reported to cost about $40,000.

Mass., Natick—The Framingham & Natick Ice Mfg. Co., 90 Pond Street, J. A. Hill, in charge, has approved plans for a one-story ice-manufacturing plant, 60 x 110 ft., reported to cost over $50,000, with equipment.

Md., Baltimore—The Consolidated Gas, Electric Light & Power Co., Lexington Building, has begun an expansion and improvement program at power plant at Westport, to cost over $500,000, with equipment. Company engineering department, G. F. Harris, engineer, is in charge.

Md., Baltimore—Dietrich Brothers, Guilford Avenue and Pleasant Street, iron and steel products, are planning installation of electric power equipment in proposed new one-story addition to cost about $60,000.

Md., Brunswick—The Town Council is said to be arranging a fund of about $100,000, for extensions in municipal water system, including installation of pumping machinery and other mechanical equipment, pipe lines, etc. A source of new supply has just been purchased.

Me., Oakland—The Getchell Foundry & Machine Co. is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss reported at over $70,000.

Mich., Ann Arbor—The Cavac Radio Corporation plans installation of electric power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss reported over $75,000.

Minn., St. Paul—The American Agricultural Chemical Co., 420 Lexington Avenue, New York, plans installation of electric power equipment in new plant for fertilizer production now projected at St. Paul, where an extensive waterfront site has been secured, entire plant to cost over $100,000.

Minn., St. Paul—The Department of Public Utilities, A. J. Conroy, commissioner, is reported planning a power plant in the vicinity of Hill and Market Streets, for electric light and power, as well as steam heating service, estimated to cost about $270,000.

Miss., Greenville—The Greenville Ice & Coal Co., Greenville, is said to have plans under way for extensions and improvements in local ice-manufacturing plant to cost about $40,000, with equipment.

N. J., Jersey City—The Public Service Electric & Gas Co., 80 Park Place, Newark, N. J., has approved plans for the construction of a two-story gas plant unit on Duffield Avenue, Jersey City, reported to cost about $65,000.

N. J., Perth Amboy—The Puritan Dairy Products Co., 683 New Brunswick Avenue, Perth Amboy, plans installation of electric power equipment in proposed new one-story plant addition, 100x400 ft., reported to cost over $100,000. The Ballinger Co., Twelfth and Chestnut Streets, Philadelphia, Pa., is architect and engineer.

N. Y., Le Roy—The Board of Trustees, LeRoy, is arranging a bond issue of $96,000, for extensions and improvements in municipal water works, and will hold a special election in February, for citizens' approval. Project will include installation of pumping machinery and auxiliary equipment.

N. Y., Long Beach—The Knickerbocker Ice Co., 41 East Forty-second Street, New York, has filed plans for a one-story ice-manufacturing plant, 100x100 ft., at Long Beach, reported to cost close to $80,000, with equipment. C. Leslie Weir, 13 East Thirty-seventh Street, New York, is architect.

Ohio, Canton—The United Engineering & Foundry Co., Canton plans installation of electric power equipment in proposed new plant addition reported to cost over $80,000, for which plans have been approved.

Ohio, Cincinnati—The Kroger Grocery & Baking Co., 35 East Seventh Street, is said to have authorized a fund of $2,000,000, for extensions and improvements in baking and other branch plants, including installation of electric power equipment, as well as steam power apparatus, ovens, etc.

Ohio, Dayton—The Dayton Green House Mfg. Co., South Perry Street, plans installation of electric power equipment in proposed new one and two-story plant unit on Miami Chapel Road, reported to cost about $80,000. Geyer & Neuffer, Ludlow Arcade Building, are architects.

Ohio, Jackson—The City Council, Jackson, is considering rebuilding of municipal electric light plant, recently destroyed by fire with loss reported at close to $30,000.

Ohio, Toledo—The International Harvester Co., 606 South Michigan Avenue, Chicago, Ill., plans installation of electric power equipment in proposed new plant on two-acre tract of land, recently acquired at Toledo, Ohio, entire project reported to cost about $300,000.

Pa., Sharon—The Sharpsville Boiler Works, Sharon, is reported planning installation of electric power equipment in connection with proposed new plant addition, entire project reported to cost more than $60,000.

S. C., Charleston—The South Carolina Power Co., Charleston, is said to be arranging an expansion and improvement program in power plants and system during 1931, to cost about $1,500,000. Work will include a number of new transmission lines. Company engineering department is in charge.

S. D., Aberdeen—The Board of Trustees, Northern Normal and Industrial School, is said to be planning the construction of a one-story steam power plant at institution, to be used primarily for heating service.

Texas, Fort Worth—The Scullin Steel Co., 6700 Manchester Avenue, St. Louis, Mo., plans installation of electric power equipment in proposed steel fabricating plant at Fort Worth, Texas, entire project reported to cost more than $1,000,000. A power house will be built. Harry Scullin is president.

Va., Roanoke—The Appalachian Electric Power Co., Roanoke, has made application to the Federal Power Commission for permission to carry out a hydro-electric power development on the New River, near the Virginia-West Virginia state line, entire project reported to cost close to $10,000,000, with transmission system.

Wash., Seattle—The Board of Public Works, Seattle, is said to be arranging an early call for bids for superstructure for proposed municipal power plant at Diablo, entire project estimated to cost about $500,000. J. D. Ross, superintendent of city lighting department, is in charge.